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ART. XLIV.—*On Diffraction Spectrum Photography;* by HENRY DRAPER, M.D., Professor of Analytical Chemistry and Physiology in the University of New York. (Illustrated by a photograph printed by the Alberttype process.)

THERE are, as is well known, two methods by which spectra may be obtained: 1st, by the action of a prism; 2d, by a system of closely ruled lines. In the latter case it is convenient to speak of the contrivance employed as a grating, and of the spectrum as an interference or diffraction spectrum. A casual inspection shows that there is a great difference between the spectra produced by these two methods, and close investigation proves that the diffraction spectrum is by far the more suitable for accurate scientific work. For this reason it has seemed desirable to make a trustworthy map of those parts of the solar diffraction spectrum which can be photographed on collodion, and to attach to it a scale for reading the wave-lengths of the rays.

The plate accompanying this memoir is from collodion phographs made by myself, transferred to a thick piece of glass, the latter process being known as the Alberttype. For the entire success of this transfer I am indebted to my friend Mr. E. Bierstadt, the owner of the patent in America. The glass is then used in a printing press in the same manner as a lithographic stone. The spectrum is absolutely unretouched. It represents therefore the work of the sun itself, and is not a drawing either made or corrected by hand.

The picture consists of two portions; 1st, the upper, which gives all the lines of the spectrum from near G to O, or from

wave-length 4350 ten-millionths of a millimeter to 3440. Above that is placed a scale, which is a copy of Angström's from just below G to H_2, with the same-sized divisions carried out from H_2 to O. The 2d, or lower, is a magnified portion of the same negative, having H_1 and H_2 about its middle, and extending from wave-length 4205 to 3736.

It follows therefore that the lines in the solar spectrum are correctly represented in their relative positions. The only errors are those which may have arisen from mal-adjustment of the scale. The precautions that were taken to avoid such errors will be described. With a certain correction, to be mentioned hereafter, it may also be stated that the relative shadings and intensities are preserved.

The value of such a map depends on the fact that it not only represents parts of the spectrum which are with difficulty perceived by the eye, (though they may be seen by the methods of Stokes and Sekulic,) but also that even in the visible regions there is obtained a far more correct delineation in those portions which can be photographed. In the finest maps drawn by hand, such as those in the celebrated "Spectre Normal du Soleil" of Angström, the relative intensity and shading of the lines can be but partially represented by the artist, and a most laborious and painstaking series of observations and calculations on the part of the physicist is necessary to secure approximately correct positions of the multitude of Fraunhofer lines. Between wave-lengths 3925 and 4205, Angström shows 118 lines, while my original negative has at least 293.

For such reasons many attempts have been made to procure good photographs of the diffraction spectrum. The earliest were by my father, J. W. Draper; his results were printed in 1843–44 in a work entitled "On the Forces which produce the Organization of Plants." This memoir was accompanied by plates drawn from his daguerreotypes, and the wave-lengths, which he first suggested as the proper indices for designating the Fraunhofer lines, were used as a scale.

Since that time the most important experiments in this direction have been by Mascart and Cornu. These eminent physicists have, however, resorted to the plan of taking portions of the spectrum on a small scale and subsequently making enlarged drawings therefrom. This course introduces the defects of handwork, and the artistic difficulties of copying intensity and shading, as well as the omission of fine lines.

In the photographs of the spectrum which I have taken, I have tried to get as large a portion as I could at once, and on as large a scale as possible. I have usually obtained images from below G (wave-length 4307) to above O (wave-length

3440) of about 12 inches (·305 meter) long. I have succeeded, however, in photographing from near *b* (wave-length 5167) to T (wave-length 3032) by resorting to a ruled speculum plane and a concave speculum mirror, but the photographic and optical difficulties in securing an enlarged spectrum of that length are great.*

Of course, in such a research as this an essential is a finely and evenly ruled plane of glass or other material. Those which I have used were made by a machine devised and constructed by Mr. L. M. Rutherfurd, whose beautiful lunar and prismatic spectrum photographs are so well known to the scientific world. The plate generally employed is of glass ruled with 6481 lines to the inch; the ruled part is $1\frac{8}{10}$ inch (·027 meter) long, and $\frac{64}{100}$ inch (·016 meter) wide. It is unquestionably much more nearly perfect than similar gratings made by Nobert and others, for the character of the photographs and the uniformity of the orders on either side of the normal, together with its behavior under a searching examination, show that it leaves little to be desired. As it is on glass, and gives a bright transmitted spectrum, I have constructed the remainder of the optical apparatus of glass achromatized, according to the plan used by J. W. Draper in 1843, except that I have not silvered the ruling, and therefore have used the refracted, and not the reflected beam. The slit is $\frac{8}{100}$ of an inch (·02 meter) long, and $\frac{1}{100}$ of an inch (·00023 meter) wide; the jaws are of steel, and there is not only a micrometer screw for separating them, but also one for setting them at an angle. Occasionally I have taken photographs with the jaws $\frac{1}{50}$ of an inch (·00028 meter) apart at the top, and $\frac{1}{100}$ (·00019 meter) at the bottom, so as to obtain different intensity in the two edges of the spectrum.

Most of the photographs have been of the spectrum of the 3d order, which has certain conspicuous advantages. In the first place, it is dilated to such an extent as to give a long image, and yet one not too faint to be copied by a reasonable exposure of the sensitive plate; and in the second place, the spectrum of the 2d order overlaps it in such a way that D falls nearly upon H, and *b* upon O. These coincidences are serviceable in determining the true wave-lengths of all the rays.

The only point of special interest in connection with the photographic part of the operation, is the device for avoiding the unequal action on the sensitive plate of different rays of the spectrum. It has been commonly supposed, until the recent memoirs of J. W. Draper, that there are in the spectrum three

* Since writing the above I have succeeded in photographing the lines of the visible spectrum from *b* downward, and the picture comprises not only the regions including E, D, C, B, *a* and A, but also the ultra-red rays. The great groups *α*, *β*, *γ*, below A, discovered by my father in 1843, are distinctly reproduced.

different types of force in three different but overlapping regions. Heat was supposed to be principally found at the less refrangible end, light in the middle, and actinism at the more refrangible. But he showed that this error has partly arisen from using prismatic spectra, which condense the red end and dilate the violet, and do not present the rays in the true order of their wave-lengths, and partly from the nature of our ordinary photographic substances. He proved that actinism, or the power of chemical decomposition, does not particularly belong to the violet end of the spectrum, but is found throughout its whole length. But bromide and iodide of silver, as used in collodion photography, are more readily decomposed by vibrations of certain lengths and periods than by others, and hence the excess of action seen at the violet end is a function of certain silver compounds, and not of the spectrum. Other substances, as carbonic acid, show maxima elsewhere, as in the yellow region. The solar beam is therefore not compounded of three forces, light, heat and actinism, but it is a series of ethereal vibrations, which give rise to one or other of these manifestations of force, depending on the surface upon which it falls.

In order to provide against this excess of action in certain parts of the spectrum, I introduced a system of diaphragms placed in the vicinity of the sensitive plate, and removed at suitable times during the exposure. The region from wave-length 4000 to 4350 only requires about one-tenth of the time demanded by that from 3440 to 3510. In the negative which produced the accompanying plate, the line O had 15 minutes and G $2\frac{1}{2}$ minutes, and the former is under-exposed. These exposures seem at first sight unusually long for a wet collodion surface, but it must be remembered that the slit used was only $\frac{1}{1\,1\,0}$ of an inch wide, and that the diffraction grating gives an almost complete circle of spectra round itself, amongst which this thin band of light is divided. A beam $\frac{1}{1\,1\,0}$ of an inch (·00023 meter) wide is spread out in this case into a streak about 78 feet (23·77 meters) long.

After the production of spectra that were in focus from end to end, it was next necessary to attach a scale to them by which the wave-lengths might be read. At first I tried, by reducing Angström's maps to the proper dimensions, to accomplish this object, but the undertaking proved to be difficult, and was unsuccessful, because, though the original drawing on the stone was undoubtedly correct, the paper proof of it which I had, had stretched unequally in printing, and on applying a photographic reduction to my spectra, coincidence could not be obtained. As, however, the subject of providing a scale for these diffraction spectra is of prime importance in giving value and precision to the wave-lengths presented in this memoir, I propose to de-

scribe fully the method eventually employed in fitting a scale to the photograph.

The wave-lengths of the ultra-violet rays have never, as far as I know, been either determined or published except by J. W. Draper in 1844, Mascart in 1866, and Cornu in 1872. J. W. Draper's memoir has a steel engraving of some of the principal lines, from which the wave-lengths may be approximately read.

The large plate which accompanies Mascart's long and valuable memoir is of the prismatic spectrum, but he furnishes in addition the following table of wave-lengths:

L	3819·0
M	3728·8
N	3580·2
O	3440·1
P	3360·2
Q	3285·6
R	3177·5

These numbers do not entirely coincide in all cases with my photograph, as I will show further on.

The detailed results of M. Cornu have not appeared in any publication that has reached me.

I have used as a basis the numbers given by Angström for the rays D_2, b_4 and G, and if there should be any small error in his determinations, my scale will require a proportionate correction, which can easily be effected. At first sight it seemed better to take G and H as fixed points, but the line H is so broad, and has so many component lines, that its position is uncertain, and moreover, being almost at the limit of visibility in Angström's apparatus, it was more open to errors of measurement. These reasons led me to take advantage of the fact that the 2d spectrum overlaps the 3d, the ray D of the 2d being near H of the 3d, and *b* of the 2d near O of the 3d. It is obvious that we have thus the means of ascertaining the wave-lengths of three points, one at each end, and one in the middle of my photograph. As the rays D and *b* cannot impress themselves on collodion by any length of exposure that it is convenient to give, and as in my method of working the ultra-violet rays could not be seen simultaneously with them, it was necessary to resort to the following device. I placed in front of the sensitive plate and close to it two fine steel points, one of which was carefully adjusted to the position of D_2 of the 2d order, and the other to b_4 of the 2d order. When therefore, after a suitable exposure to the ultra-violet spectrum of the 3d order, the collodion picture was developed, there were two sharply defined images of the steel points superposed on the spectrum. The point which had been coincident with D_2 of the 2d order was

then found to have cast its shadow on H_2 of the 3d order, and the point at b_4 of the 2d order had impressed itself near O of the 3d order.

By a simple calculation it was thus rendered evident that a given ray in the compound line H_2 was of the wave-length 3930·1 ten millionths of a millimeter, and that another line near O had the wave-length 3444·6. By looking at the photograph, the reader will see that 3930 falls upon a fine division in H_2, which is beautifully shown in both the spectrum with the scale and the enlarged proof below. Of course, the ray G of the 3d order, the wave-length of which is known, had impressed itself photographically on the collodion.

Having thus ascertained the wave-lengths of three fixed points in the photograph, the next step was to apply a scale reading to a single ten-millionth of a millimeter, and, if possible, fractions thereof. After many abortive attempts to use that part of Angström's map which lies between G and H, and to attach thereto an additional length of scale sufficient to extend to the end of the ultra-violet region, I was compelled to resort to a linear dividing engine, and rule a scale which was about twice the length of the photographic reduction shown in the accompanying plate. Of course, this necessitated drawing in by hand the same systems of lines and lettering as are shown on Angström's chart, and this I did as carefully and faithfully as I could.

It only remained to reduce this divided scale to the proper size to fit the spectrum photograph; after many trials it was accomplished.

It is proper in this place to make a criticism on my scale, and to point out a small error, which may be due, however, to an incorrect determination of the wave-lengths that I have used as fixed points. Taking the distance from G (wave-length 4307) in the photograph to the fixed line 3930 in H_2, and dividing it into 377 parts, and then prolonging these divisions toward O, it was found that the third fixed point was not attained, but that there was an error of about two divisions. But if the position of D_2 in Angström's determinations should be incorrect to the extent of one ten-millionth of a millimeter, or if this small error should be partly attributed to D_2, and partly to G, my scale would be correct. Future measures of the wave-lengths of these rays, and of b_4, can alone settle this delicate point, for the determinations of Mascart and Angström and Thalen differ nearly to the extent mentioned above. The same remark is true of Angström compared with Ditscheiner, while the difference between Angström and van der Willigen is more than three times the amount necessary to remove my discrepancy. In any case the photograph is correct, as it is the

work of the sun, and is only open to errors arising from imperfect flatness in the field of a fine lens, and that field only subtending an angle of about 4°. The angular aperture of the lens viewed from the sensitive plate is 20 minutes. I trust, therefore, that the photograph may be of permanent value to physicists, for any one can affix another scale if this be slightly erroneous.

An examination of the photographed spectrum shows many points of interest, some of which are best seen in the spectrum with the scale above, and some in the portion enlarged below. The latter is magnified about twice, and comprises the region from wave-length 3736 to 4205. I have also made photographs on the same scale as Angström's map, but have not as yet printed them. The capital letters which are attached to the region above H, are according to the nomenclature of Mascart, although the wave-lengths assigned by him to those letters do not coincide exactly in all cases with the lines in my photograph; for instance, the line L, which he regards as single, is in reality triple, and does not correspond to 3819, but to 3821; M is correctly designated by 3728, but it is double; N is really at 3583, and not 3580. It has been suggested that it would be proper to return to the old nomenclature of Becquerel and J. W. Draper, who simultaneously discovered these lines in 1842–43, but the designation of position by wave-length in reality renders the letters unnecessary.

The spectrum above H, when compared with the region from G to H, is marked by the presence of bolder groups of lines, and most conspicuous are those between 3820–3860, 3705–3760, 3620–3650, 3568–3590, 3490–3530. The first of these groups is strikingly shown in the enlarged photograph. I am not as yet able to offer an opinion as to the chemical elements producing these groups, for almost all the photographs of the ultra-violet spectra of metalline vapors that I have thus far made were produced by a quartz train, and have not yet been reduced to wave-lengths. Indeed, that is a separate field of inquiry, and could not be comprised in a memoir of this length. I have also tried to utilize the photographic spectra of the late Prof. W. A. Miller, published in the Transactions of the Royal Society for 1862, but for some reason, probably insufficient intensity of the condensed induction spark, his pictures do not bring out the peculiarities of the various metals in the striking manner that is both necessary and attainable. The diffraction spectra of metalline vapors that I have made are not yet ready for use.

The probabilities are that each of these groups will be found to be due to several elements, as is plainly seen in the group H. This compound line, which is commonly spoken of as being caused by calcium, iron and aluminum, is in reality much more

complex, for there can readily be counted in it more than fifty lines in the original negative, and a careful inspection of the accompanying paper picture shows a large proportion of them. This observation leads us to a more general statement. *The exact composition of even a part of the spectrum of a metal will not be known until we have obtained photographs of it on a large scale.* The coincidences which were so thoroughly examined by Mr. Huggins (Trans. Royal Society, Dec., 1863), will only disappear when we can, in addition to the position of a line, have a clear idea of its size, strength and degree of sharpness or nebulosity. The eye is not able to see all the fine lines, or even if it does, the observer cannot map them with precision, nor in their relative strength and breadth. For example, in Angström's justly celebrated chart, of which the G–H portion is copied in this plate, and in the construction of which the greatest pains were taken by him, many regions are defective to a certain extent. The region from 4101 to 4118 is without lines, yet the photograph shows in the enlarged copy seventeen that can easily be counted, and the original negative shows more yet. The reader of course understands that a paper print of a collodion picture is never as good as the original; the coarseness of grain in the paper, want of contact in transferring, etc., effect such a result. Moreover, the Alberttype process depends on a certain fine granulation which is given to the bichromated gelatine, and this forbids the use of a magnifier upon these paper proofs. It is only just, however, to Mr. Bierstadt to state, that without his personal supervision, such sharp and fine-grained proofs could not have been obtained, and that no other printing-press process that I know of could have accomplished this work at all. As an illustration of the difficulty of depicting the relative intensity of lines, we may examine 3998, which in Angström's chart is shown of equal intensity with 4004, while in reality it is much fainter, and instead of being single, is triple, as is well seen in the enlarged spectrum.

When, however, we compare Angström's chart with the photograph, it requires, as the above remarks show, a critical examination to detect defects, and we have a striking confirmation of the surprising accuracy of the Swedish philosopher.

So also in comparing Mascart's excellent map of the prismatic spectrum with the photograph, the difficulty of depicting all the fine lines is seen. In the group L he shows twelve lines, while even in the Alberttype copy of my photograph twenty-five can be counted, and in the original negative many more. From H to L he exhibits seventy lines; in my plate 138 can be observed, besides many unresolved bands.

In the earlier part of this memoir, it was stated that the relative intensities of the lines in the spectrum were correctly repre-

sented if a certain allowance was made. If an unshielded collodion plate were presented to the image of the spectrum, there would be produced a stain very dense from G to H, fainter above H, and still fainter below G. But this stain would not represent the actinic force of the sun; it would merely be the index of the decomposability of a mixture of iodide and bromide of silver. I have for this reason adopted the idea of J. W. Draper, that force is equally distributed through the spectrum, and have tried to produce a photograph of equal intensity throughout. This has been accomplished, as I have before stated, by suitable diaphragms. But whether this view be correct or not, lines which are not far distant from one another are presented virtually without any interference by diaphragms, and must therefore be correct both as to shading and intensity.

Besides the points above mentioned, there are many theoretical considerations suggested by the photograph which it does not seem expedient to enter upon fully at present. Among such is the possibility of arriving at an estimate of the sun's temperature, by interpreting the apparent bands, such as those near G and H, by the aid of Lockyer's researches on the temperature of dissociation of compounds. No one has yet ascertained whether there are or are not unresolvable bands in the solar spectrum. If they do exist, the compounds to which they belong, and the necessary temperature for dissociation, remain to be determined.

It would seem also to be possible to find out whether, as asserted by Zöllner, there is a liquid envelope around the sun, by a search for more diffused bands in its photographed spectrum.

In the hope that this photograph may prove to be of value to scientific men for further investigations upon the sun and the elements, I have caused a number of extra copies to be printed, and shall be glad to present them to any one who can make use of them.

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ART. XLV.—*Notes on the West Virginia Asphaltum Deposit;* by WM. M. FONTAINE, Professor of Nat. Hist. Univ. of West Virginia.

IN Ritchie County, West Virginia, occurs a remarkable deposit of bituminous matter, for which the name "Grahamite" has been proposed.

This substance, in its chemical properties, is strikingly like the mineral "Albertite," of New Brunswick, while in its geological relations it differs considerably from it. Like

"Albertite," it is mined and used for the production of gas. It is highly valued as an enricher of the common coal used in the manufacture of this substance. The value of the mineral has led to the extensive working of the deposit by a company of Baltimore capitalists, who transport the material by a branch road of their own construction to Cairo Station, on the Baltimore and Ohio Railroad.

The asphaltum deposit occurs in the county of Ritchie, on McFarland's Run, a branch of Hughes River, nearly 12 miles due south from Cairo. To reach it, the branch railroad passes, by a series of zigzags, over hills upward of 500 feet high, thus disclosing quite an extensive series of strata, the nature of which, by means of the railroad cuttings and the excavations at the mines, may be easily made out.

The geological formation here disclosed is that known as the "Upper Barren Measures," being a portion of the strata above the Pittsburg Bed which are unproductive of coal. These barren strata, lying toward the center of the Appalachian coal basin, and being consequently the highest in the series, are in this portion of the State greatly developed, and present some noteworthy features. For this reason, and also because no measurements, as far as I know, have been made of these rocks, I will give the section from the level of the mines to the summit of the hills, which rise some 520 feet above them; the culminating point being 2½ miles distant. In this will be included the strata which lie below the mine level, and have been penetrated by the workings. These have penetrated 160 feet below the surface, which distance, with the 520 feet disclosed along the railroad, gives us a vertical section of 680 feet.

The lowest stratum reached in the mine is a red shale, which has not been penetrated; its thickness is consequently unknown. The section commencing at the bottom is as follows: 1. Red shale, thickness unknown. 2. Gray shale, 20 feet. 3. Sandstone, 30 feet. 4. Gray shale, 55 feet. 5. Sandstone, 95 feet. 6. Gray shale, 55 feet. 7. Sandstone, 35 feet. 8. Gray shale, 45 feet. 9. Sandstone. The strata from 1 to 8 inclusive are embraced within the limits of the mine, and their thickness and nature are well ascertained. The remaining 345 feet of the section, commencing with No. 9, are not so well known, since No. 9 overlies the asphaltum deposit, and caps the hills in the immediate vicinity, while the overlying rocks are imperfectly disclosed along the line of the railroad to the summit. They are, however, sufficiently revealed to show that they are a succession of flaggy sandstones and gray shales, succeeding each other in the same order as is found in the mines. None of the strata denominated shales in this section are purely so. They contain throughout their thickness many very

thin layers of sandstone; but the shaly layers vastly predominate. So again, most of the sandstones are flaggy from the intercalation of shaly strata. Two of the sandstones disclosed in the mine, however, present notably different features from these, and from their important influence upon the width of the crevice which penetrates them, deserve a special description. These are Nos. 3 and 5. Both present the same characters; hence we need describe only the more important stratum, No. 5.

The greater portion of the sandstones seen in this section are quite argillaceous, and hence are more or less strongly colored, fragile and flaggy. On the contrary, No. 5 is often quite free from impurities, presenting very compact, heavy bedded, pure white masses of sandstone; sometimes forming a decided conglomerate. The striking physical features of this rock render it a conspicuous feature in the hills, and its indestructible nature causes it to exert a predominating influence on the topography of the region in which it appears. The lofty elevations and precipitous cliffs, seen from the railroad in this section of the State, are due to its appearance in the hills, and the preservation of the underlying strata thus caused. This stratum is much like the great conglomerate, which serves as the floor of the coal formation. It is interesting to note the fact thus indicated, that the conditions of deposit during the last period of the Appalachian coal era, at least in the center of the basin, so closely resemble those prevailing in the earliest.

The dip of the strata is imperceptible, and no indications whatever exist of displacements. Indeed, no evidence exists elsewhere than at the mines of any break in the continuity of the formations, unless it be that more cracks and fractures, on a small scale, exist than are usually found in the sandstones of the Coal-measures. I think that I did observe some such evidences of the rocks being shattered without displacement, but on this fact I cannot insist, as I had no opportunity to make examinations sufficiently extensive to establish it conclusively.

The observer accustomed to the abundant evidences of the former existence of vegetation, as seen in the underlying strata of the productive portions of the coal group, is most forcibly struck with the total absence in these rocks of even discoloration from carbon. The prevailing tint of the sandstones and shales is gray, which in some is changed by weathering to dull brown. No dark shales exist, and in the whole vertical distance, but two thin beds of coal are found, and these present every evidence of turbulent conditions having attended their formation Each of these beds is about 12 inches thick. One, the lower, is seen about a mile from the mine, occurring near the top of the gray shale No. 2. It has not been discovered in

working the mineral, being, no doubt, too locally developed to exist there. The second is seen near the mine, and occurs near the top of the gray shale No. 6. Each bed is thus found on the top of a heavy stratum of gray shale, and is capped by a heavy bed of sandstone. The recurrence in regular order of the same character of rocks, in our section, and, so far as they have been measured, with nearly the same thickness, is somewhat singular. We thus see that in the geological horizon of our mineral, and the conspicuous absence of material to produce bituminous matter, we have the exact opposite of the conditions prevailing at the locality of the Albertite deposit of New Brunswick. It will be remembered that this occurs at the base of the Carboniferous formation, and in intimate connection with a heavy stratum of bituminous shale.

Here, also, we have no anticlinal folds, as in the Albertite region.

The cleft which contains the deposit is without doubt caused by the fracturing and slight displacement to one side of the strata. Its direction is 12° north of west. In the vicinity of the mines, it is crossed obliquely by McFarland's Run, a tributary of Hughes River, and here flowing in a southwest direction. This run has trenched the strata quite considerably, having cut out a narrow valley about 200 feet deep. Into this, a smaller stream, called Mine Run, empties near by. This latter flows nearly north and south, and thus cuts the deposit nearly at right angles, at a distance of 1,250 feet from the valley of McFarland's Run. In the sides of the deep ravine, cut by Mine Run, the deposit was first discovered, presenting the appearance of a vertical band, 4 feet wide, cutting the hills from top to bottom. The deposit has been worked vertically through a distance of 300 feet, and, horizontally, of 3,315 feet. Singular to say, all traces of the mineral disappear in crossing the valley of McFarland's Run. Not a sign of the crevice, or mineral, is seen on the east side of this stream, although the deposit continues with unchanged width until it reaches the west side, where it ends abruptly not 100 yards from the east side.

The mineral has been traced about a quarter of a mile beyond the west termination of the works, but it is there reduced to a mere string. If we continue in the direction of the crevice, about seven miles beyond this point, we would intersect at right angles the remarkable line of upheaval along which the oil wells of West Virginia are found, and which is called here the "oil break." No one who examines the crevice containing the asphaltum, and then this belt of rocks, so strangely upheaved in the midst of horizontal strata, can resist the belief, that both these disturbances of the strata had a common cause,

and that the same bituminous deposits, lying far beneath the surface, have produced the asphaltum, and now afford the oil of this region. I do not propose to set up any theory to account for this state of things, but will confine myself to a statement of the facts, so far as I could discover them.

As stated, the crevice penetrates vertically the strata from the surface to an unknown depth. Its width varies with the nature of the rocks through which it passes. Its average width in the massive sandstone No. 5 is 4 feet; and in this stratum its dimensions are greatest. We can stand in this portion of the cleft and see the mouth of the adit, 900 feet distant, an evidence of its perfect straightness; while, for the vertical distance of 95 feet (the thickness of the stratum), a plumb line from the top would not touch the sides. On passing into the shales, however, the width is diminished, being sometimes not more than 2½ feet. The direction is also slightly changed from the true perpendicular at the junction of the shales and sandstones. We see, in the shaly portions, slickensides and other evidences of rubbing and sliding. Some of the beds of sandstone have a good deal of shaly matter interstratified, and in these the crevice loses width, and becomes more crooked horizontally; but in no case in the main workings are the variations from regularity very great. In the deepest portions which have been reached, all the rocks have more shaly matter, and hence the greatest width here is only about 2½ feet. Followed to the west, all the strata, even No. 5, become more and more shaly; accordingly, in this direction also, we find the crevice closing up. I followed the opening in this direction, in the stratum No. 5, as far as the work has been carried, and found that here it had become only 8 inches wide, thus being no longer workable. Before attaining this minimum width, the crevice discloses more and more irregularity. The walls are no longer smooth, straight and vertical; zigzags and projecting shoulders are more frequent, while the crevice is continually becoming narrower. "Horses" are found in all parts, but I saw more of them here. I have but little doubt that to the west the inferior compactness of the strata has distributed and confused the action of the rupturing force, and thus prevented the formation of a clear, wide crevice.

We may, I think, from these facts, conclude that this rupturing force could not have been shrinkage.

These facts were observed in the portion of the mines lying to the west of Mine Run. The character of the cleft to the east of the run is similar. This portion is 1,250 feet long, lying in the tongue of land between this stream and McFarland's Run, when, on emerging near the latter, with unchanged width, it suddenly vanishes.

There is a considerable lateral pressure exerted on the mineral from the tendency of the walls to close in. As it is removed by the pick, the sudden yielding of the remaining portions is denoted by a series of pistol-like reports. The movement, however, is imperceptible.

To the casual observer the appearance of the mineral in the cleft is much like that of ordinary bituminous coal. But a closer examination shows, in any given section, that the mass is composed of two portions, quite different in physical properties. These always occupy the same relative position. The one is found only on each side, next to the walls, having a thickness depending on the width of the cleft. The other occupies the central position, and seems to be more independent of the varying width of the crevice, being generally about 15 inches thick. We thus have the entire thickness composed of three bands, the inner differing from the outer enclosing portions.

The outer portions next to the walls have a jet black color and brilliant luster, with eminent cleavage in two directions perpendicular to the walls, causing the substance to break into short prisms. The fracture across, or in the plane parallel with the walls, is flat conchoidal. The color of the streak on porcelain is brownish black, nearly quite black. This portion, as well as the inner, is very friable, causing the production of fine powder on handling.

The inner portion has a dark steel gray color, and resinous luster in part, and in part is dull. This dead-looking inner portion contrasts strikingly with the brilliant outer portion. Its structure in the mass is irregularly and coarsely prismatic, while its intimate structure is finely flat fibrous, intermixed with very small plates, similar in appearance to the outer portion. The change in color and luster of the inner portion seems mainly due to the greater fineness of the texture, though there may be some difference in chemical constitution. As stated, this inner portion seems in its thickness to be more independent of the width of the crevice than the outer portion; for when the mass is reduced to a thickness of 8 inches, this is still 5 inches thick, while it is never more than about 18 inches, even in the most massive portions of the deposit.

The same arrangement of these two varieties of the mineral is seen around the "horses," or fragments of the walls, which have fallen into the mineral, and then become imbedded. We always find a thickness of several inches of the brilliant black portion in contact with the "horse." This seems to show that this modification of the mineral is a species of crystallization, produced next to the cooling or evaporating surface.

These imbedded fragments are always colored throughout

their mass a dark gray, from impregnation with bituminous matter. The original color is nearly white. Singular to say, the enclosing walls show this discoloration hardly ever to the depth of an inch. The mineral adheres slightly to the rock, and may be removed with the fingers. It presents much such an appearance as tar would, when hardening in contact with stone, while assuming a prismatic structure.

No "strings," or "feeders," of the main crevice are to be seen, nor does the mineral penetrate at all the shaly partings or crevices along the bedding of the strata, while it insinuates itself into quite small openings running in the direction of the cleft. These paper-like seams are sometimes found between the wall and a loosened fragment. This behavior is very remarkable, and would seem to forbid the idea that the substance could have been very fluid or subjected to much pressure vertically; while it may have been forced along *a tergo*.

Some of these peculiar features may be explained by the following assumptions.

We may suppose an open crevice formed, and then filled by the inflowing of a semi-fluid bituminous compound, which hardened rapidly on coming in contact with the porous sandstone walls. Its fluidity may have been due to the presence of a vaporizable liquid, like naphtha, which could easily penetrate the sandstone walls, thus causing the seeming crystalline structure on the outer portions, and the lack of discoloration of the rock. This evaporating fluid may have met with more obstruction in passing through a stratum of bituminous matter, and hence the present impregnation by it of enclosed fragments of rocks, and hence also the imperfect development of structure in the inner mass.

If this be true, the inner portion should be richer in volatile matter, but so far as I know, no comparison has been made. At least, we know that there do exist heavy oils having nearly the character of our assumed liquid.

I know of but one analysis of the mineral, that by Prof. Wurtz. I am informed that this has been verified, in the main, by subsequent ones. This is as follows: Sp. gr. 1·145. Composition: C 76·45, H 7·83, O 13·46, Ash 2·26, traces of S and N. For the behavior of the mineral with solvents and heat, the article in Dana's Mineralogy, on Grahamite, may be consulted.

It yields theoretically 140 gallons of oil per ton; practically, about 100 may be secured. The fine dust produced by handling the mineral is capable, when very dry, of inflaming from an open lamp. This has led to two accidents from explosion. The dry dust having caught fire in the lower levels, the gasous products became mixed with air in the upper works and exploded.

The facts obtained by me in my examination of this interesting deposit are the more trustworthy and general, from the information afforded me by the intelligent superintendent of the mines, Major Glenn. This gentleman is an accomplished civil engineer, and his training as such caused him to study closely every feature of the deposit, thus enabling him to furnish me with a mass of details which I could not otherwise have obtained.

Morgantown, West Virginia, Oct. 14.

ART. XLVI.—*On the Magnetic Permeability* and the Maximum of Magnetism of Iron, Steel, and Nickel;* by HENRY A. ROWLAND, C.E., Instructor in Physics in the Rensselaer Polytechnic Institute, Troy, N. Y.†

IN all mathematical theories of induced magnetization a quantity is introduced depending upon the magnetic properties of the substance, and without a knowledge of which the problem is of little but theoretical interest; this quantity has always been treated as a constant, although the known existence of the maximum of magnetization showed it to be otherwise: the reason of this may perhaps be traced to a formula which Müller has given to represent the magnetization of an electromagnet, and to the extreme difficulty of treating the subject in any other way. These quantities as used by different persons are as follows:—

k, Neumann's coefficient, or magnetic susceptibility (Thomson).
K, Poisson's coefficient.
μ, coefficient of magnetization (Maxwell), or magnetic permeability (Thomson).

The relations of these quantities are given by the following equations:—

$$k = \frac{4\pi K}{4\pi K + 3} = \frac{\mu - 1}{\mu + 2}$$

$$K = \frac{\mu - 1}{4\pi} = \frac{3k}{4\pi(1-k)}$$

$$\mu = \frac{1+2k}{1-k} = 4\pi K + 1.$$

Very few determinations of any of these quantities have been made in the case of iron and none in the case of steel,

* This word "permeability" has been proposed by Sir. William Thomson to replace "conductivity" as used by Faraday. (Thomson's "Papers on Electrostatics and Magnetism" p. 484. Maxwell's "Electricity and Magnetism," p. 51.)

† Abstract of a paper in the Philosophical Magazine, August, 1873, prepared for this Journal by the Author.

nickel, and cobalt; neither has the form of the function by which these quantities are connected with the degree of magnetization been attempted, except so far as we may consider the erroneous formula of Müller, above referred to, as such an attempt.*

In a preliminary experiment to determine on the mode of experiment to be adopted, it was shown that the distribution of magnetization in an electromagnet varied with the strength of the exciting current, so that no arrangement to measure the magnetization of the bar which is based on the deflection of a compass needle can give correct results. This has been theoretically anticipated by Sir W. Thomson.†

I believe mine are the first experiments hitherto made on this subject in which the results are expressed and the reasoning carried out in the language of Faraday's theory of lines of magnetic force. That my choice is a proper one and my results correct needs no further proof than that given in Prof. J. Clerk Maxwell's "Treatise on Electricity and Magnetism," where this theory is thoroughly worked out and shown to give exactly the same results as the older theories, where the action is assumed to take place at a distance without intervening matter. I believe there are great things in store for this theory, and its excellent working qualities are shown in the method of measuring magnetism in absolute measure adopted, for which I claim that it is the most simple and accurate of any yet devised, and which was suggested to me while thinking of the matter according to this theory.

The absolute units to which I have reduced my results are those in which the meter, gram, and second, are the fundamental units. The unit of magnetizing force of helix I have taken as that of one turn of wire carrying the unit current per meter of length, and is 4π times that of the unit magnetic field. The magnetizing force of any helix is reduced to this unit by multiplying the strength of current in absolute units by the number of coils in the helix per meter of length. These remarks apply only to endless solenoids and to those which are very long compared with their diameter. The unit of number of lines of force I have taken as the number in one square meter of a unit field measured perpendicular to their direction.

In working out the theory of the operation, at first I used an equation which I obtained some time ago for the distribution of magnetism on a bar or ring magnet, but as I cannot here go through with the process of getting the equations, I will give the following method. If n is the number of coils per meter

* I do not include here the theoretical formulæ of Weber and Maxwell, as they lack the test of experiment.

† Papers on Electrostatics and Magnetism, p. 512.

of helix and n' the total number on a ring magnet, i the strength of current, and ρ the distance from the axis of the ring to any point in the interior of the ring-solenoid, the magnetic field at that point will be* $2n'i\frac{1}{\rho}$, and at a point within an infinitely long solenoid $4\pi in$. If the solenoid contain any magnetic material of magnetic permeability μ, the field will be for the ring $2n'i\frac{\mu}{\rho}$ and for the infinite solenoid $4\pi\mu in$.

Therefore the number of lines of force in the whole section of a ring-magnet of circular section will be, if a is the mean radius of the ring,

$$Q'=4n'i\mu\int_{-R}^{+R}\frac{\sqrt{R^2-x^2}}{a-x}=4\pi n'i\mu(a-\sqrt{a^2-R^2}),$$

or since $n'=2\pi an$ and M, the magnetizing force of helix, $=in$, we have, by developing

$$Q'=4\pi M\mu(\pi R^2)\left(1+\frac{1}{4}\frac{R^2}{a^2}+\frac{1}{8}\frac{R^4}{a^4}+\&c.\right)$$

For the infinite electromagnet we have in the same way

$$Q'=4\pi M\mu(\pi R^2).$$

When the section of the ring is thin, these two equations become the same and either gives

$$\mu=\frac{Q'}{4\pi M(\pi R^2)},$$

from which the value of μ can be found when we have simultaneous values of Q′ and M in absolute measure.

The apparatus to measure Q′ was based upon the fact discovered by Faraday, that the current induced in a closed circuit is proportional to the number of lines of force cut by the wire. For measuring the induced currents a modified form of Thomson's galvanometer was used: the mirror was quite large and the needle loaded to make it vibrate slowly: the needle was astatic to prevent external magnetic forces from affecting it, and sufficient directive force was given by a magnet above: the deflections were read by a telescope and scale.

To measure M a tangent-galvanometer was used, but as I wished to measure currents varying in strength several hundred times, several coils were used and connected with binding screws, so that from one to forty-eight turns could be placed in the circuit at pleasure. The value of each coil in producing deflections was experimentally determined by a method which I shall soon publish.

* Maxwell's Treatise on Electricity and Magnetism, vol. ii, p. 284.

The magnetizing current made its circuit in the following manner (see fig. 1). The current from the battery A passed to a

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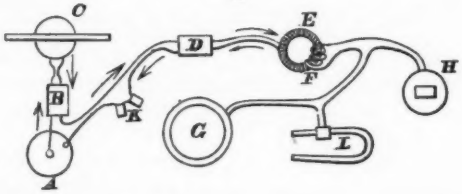


commutator B, thence to the tangent-galvanometer C, thence to another commutator D, thence around the magnet E (either a ring or a very long bar magnet): in returning it passed through some resistance coils K, by which its strength could be varied, and thence back to the battery. The induced circuit by which the magnetism of the magnet was to be measured included the following: a coil of wire F around the magnet, a large coil of wire G, the Thomson galvanometer H, and a small coil of wire sliding on one branch of a horseshoe magnet L: by sliding the latter back and forth, induced currents could be sent through the wire by which the needle could be brought quickly to rest. The theory of measuring Q′ is as follows. When the current through the magnet E is reversed by the commutator D, a current is induced in the coil F surrounding the magnet due to twice cutting the lines of force passing through the magnet and giving a deflection to the needle of h scale divisions. Now when the coil G, placed on a horizontal surface, is turned over, an induced current is produced due to twice cutting the lines of force which pass through the coil from the magnetism of the earth and giving a deflection to the needle of c units. The induced current in either case is proportional to the number of turns in the helices F or G and to the number of lines of force cut by those helices. It is evident then that the number of lines of force passing through the magnet in the unit we have chosen will be given by

$$Q' = 2n'(6{\cdot}27 \sin 74^\circ\ 50')\pi R_1^2 \frac{h}{2nc},$$

where n' is the number of coils in the ring G, n the number in the helix F, R_1 the radius of G, 6·27 the total magnetism of the earth at this place (meter, gram, second, system), and 74° 50′ the dip. The quantity $2n'(6{\cdot}27 \sin 70^\circ\ 50')\pi R_1^2$ is a constant for the coil and had a value of 14·51.

As a test of the whole arrangement, I have obtained the number of lines of force in a very long solenoid: the mean of two solenoids gave me $Q' = 12{\cdot}67\ M(\pi R^2)$, while from theory

we obtain $Q' = 12{\cdot}57\ M(\pi R^2)$, which is within the limits of error in measuring the diameters of the solenoids. &c.

All the rings and bars with which I have experimented have had a circular section. In selecting the iron, care must be used to obtain a homogeneous bar: in the case of a ring I believe it is better to have it welded than forged solid; to get the greatest permeability it should then be well annealed and *afterward* have the outside taken off *all round* to about $\frac{1}{8}$ of an inch deep in a lathe. This is necessary because the iron is "burnt" to a considerable depth by heating even for a moment to a red heat, and a sort of tail appears on the curve showing the permeability which is not normal. To get the normal curve of permeability, the ring must only be used once; and then no more current must be allowed to pass through the helix than that with which we are experimenting at the time. If by accident a stronger current passes, permanent magnetism is given to the ring, which entirely changes the first half of the curve.

In the following tables $Q = \frac{Q'}{\text{area of section}}$ has been measured as previously described. It is evident that if, instead of reversing the current, we simply break it, we shall obtain a deflection due to the temporary magnetization alone. In this manner the temporary magnetization has been measured; and on subtracting this from Q we can obtain the permanent or residual magnetization.

The following abbreviations are made use of in the tables, the other quantities being the same as previously described.

C.T.G. Number of coils of tangent-galvanometer used.
D.T.G. Deflection of tangent galvanometer.
D.B. Deflection from helix on breaking current.
Q. Magnetic field in interior of bar (total).
T. " " of bar due to temporary magnetization.
P. " " " " permanent "

$$Q = T + P.$$

Each observation given is almost always the mean of several. D.T.G. is the mean of four readings, two before and two after the observations for Q′ and T.; D.C. is the mean of from four to ten readings; D.F. mean of three; D.B. mean of two except in table I, where the deflection was read only once. In all the tables the column containing the temporary magnetization, T, can only be accepted as approximate, the experiments having been made more to determine Q than T.

The value of n was generally varied by coiling a wire more or less times around the ring, but leaving its length the same.

The change in the value of D.C. is due to change in the resistance of the circuit from change of temperature.

The following tables contain some of my results, the first two being from the same ring.

TABLE I.—"*Burden Best*" *Iron, Normal.*

C.T.G.	D.T.G.	M.	C.	*n*.	*h*.	$\frac{h}{2n}$	D.B. $\frac{}{n}$	Q.	μ.	μ. calculated.	T.
48	4°·5	·1456	23·4	30	6·5	·1083	·08	714·7	390·7	465.2	528·
"	16°·45	·5501			54·6	·910	·59	6005·	868·7	866·2	3894·
"	20°·2	·6815			87·9	1·465	·80	9667·	1129·	1120·	5280·
"	28°·6	1·011	23·3	10	74·2	3·71	1·34	24600·	1936·	1910·	8882·
"	31°·1	1·119			88·2	4·41	1·48	29230·	2078·	2073·	9811·
"	31°·9	1·155			92·6	4·63	1·53	30820·	2124·	2122·	10180·
"	41°·12	1·623		2	29·8	7·45	2·00	49590·	2433·	2446·	13310·
27	28°·35	1·766	23·1		32·8	8·20	2·50	54820·	2470·	2471·	16710·
"	29°·6	1·861			34·6	8·65	2·65	57820·	2472·	2475·	17710·
"	33°·4	2·162	23·1		39·8	9·95	2·85	66510·	2448·	2449·	19050·
"	37°·45	2·512			44·7	11·18	3·05	74730·	2367·	2382·	20·390
"	44°·45	3·223			53·5	13·38	3·85	89430·	2208·	2180·	25740·
9	52°·10	4·225			60·3	15·08	4·85	100800·	1899·	1968·	32420·
"	34°·65	6·744			73·1	18·28	7·10	122700·	1448·	1465·	47680·
"	39°·8	8·136	23.0		77·3	19·32	7·90	129700·	1269·	1284·	53040·
"	44°·3	9·542		1	40·6	20·30	9·10	136300·	1137·	1108·	61100·
"	55°·10	14 04			43·5	21·75	9·8	145400·	824·1	856·3	65510·
3	42°·95	27·18			47·4	23·70	11·5	157700·	461·8	505·3	76540·
"	51°·30	36 60			49·1	24·55	12·7	162700·	353·8	359·9	84180·
"	60°·15	51·18	23·4		50·3	25·15	13·2	166000·	258·0	263·4	87120·
								175000·		0	

TABLE II.—"*Burden Best*" *Iron, Magnetic.*

M.	Q.	μ.	M.	Q.	μ.
·1456	426	232·	2·930	82720·	2247·
·5699	3346	476·	4·210	100900·	1906·
·6962	5700	652·	6·769	122800·	1444·
1·080	24350	1795·	7·273	124300·	1360·
1·191	29280	1956·	7·626	127100·	1326·
1·537	46150·	2389·	11·10	139500.	1000·
1·590	49070	2408·	13·61	144700.	846·
1·933	59680	2456·	22·10	154600.	554·
2·377	71660	2399·			

TABLE III.—*Bessemer Steel, Normal.*

M.	Q.	μ.	T.	M.	Q.	μ.	T.
·1356	327·	192·	309·	2·756	39960·	1154·	13080·
·2793	817·	238·	727·	3·219	50550·	1250·	16350·
·5287	1726·	260·	1471·	3·551	58310·	1262·	15980·
·9398	3833·	325·	3106·	4·469	71380·	1271·	18340·
1·421	7702·	431·	5576·	5·698	85530·	1195·	23610·
1·880	14080·	596·	8972·	11·44	119550·	832·	28020·
1·947	15420·	630·	8938·	20·69	138300·	532·	41360·
2·300	24830·	859·	11320·	38·99	153700·	314·	52930·

TABLE IV.—*Norway Iron, Magnetic.*

M.	Q.	μ.	T.	M.	Q.	μ.	T.
·1344	865·	512·		2·290	105900·	3680·	35240·
·2673	2550·	759·	1892·	4·393	134100·	2429·	54970·
·5161	13000·	2005·	5857·	5·910	142400·	1917·	62810·
·5572	15310·	2187·	8110·	7·874	149100·	1507·	68490·
·6725	30140·	3567·	8921·	13·77	156800·	906·	77060·
·9305	53800·	4602·	13970·	26·84	165800·	480·	84710·
1·362	77700·	4545·	21630·	36·86	168500·	364·	87860·
1·788	93000·	4140·	28200·				

TABLE V.—*Cast Nickel, Normal.*

M.	Q.	μ.	T.	M.	Q.	μ.	T.
1·433	852·	47·4		13·43	27100·	160·6	11260·
2·904	2377·	65·1		16·53	31050·	149·5	13530·
3·527	3685·	85·1		21·02	34950·	132·3	16480·
5·555	10080·	144·4		32·17	41980·	103·8	22300·
6·783	13680·	160·5	5120·	33·92	42650·	100·0	23360·
7·401	15270·	164·2	5614·	60·91	50860·	66·4	29540·
9·273	19600·	168·2	7644·	82·36	53650·	51·8	33460·
11·78	24720·	167·0	9902·	105·2	55230·	41·8	35120·

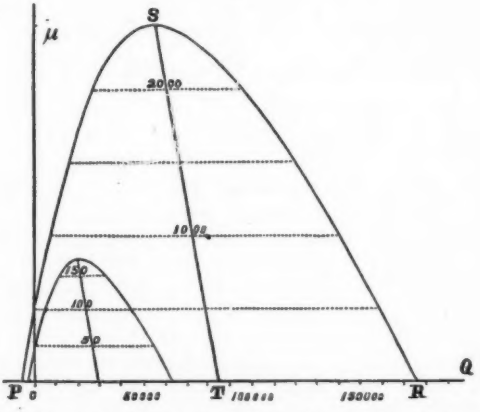
TABLE VI.—*Stubs' Steel Wire, Normal.*

M.	Q.	μ.	T.	M.	Q.	μ.	T.
·1673	159·	75·9		13·65	54300·	316·6	20900·
·6237	678·	86·5	598·	19·35	77770·	319·9	29480·
1·084	1197·	87·9	1101·	27·43	100800·	292·6	38590·
2·043	2448·	95·4	2257·	33·39	111300·	265·4	45110·
2·714	3446·	101·0	3095·	35·58	115000·	256·9	45950·
4·221	6278·	118·4	5145·	38·64	119400·	246·0	48060·
10·26	33700·	261·5	16170·				

The best method of studying these tables is to plot them: there are several ways in which this can be done, but the two best are as follows. The first is to take the value of M as the abscissa and the value of Q, T, or P, as the ordinate, thus obtaining curves showing the variation of the total, temporary, and residual magnetization with the magnetizing force. Müller, from his experiments on iron bars, has deduced a formula to represent this curve for Q, but it fails entirely for weak magnetizing forces even when applied to his own experiments, and when applied to mine it widely diverges from experiment.

Weber and Maxwell* have obtained equations from the theory that the particles of a body are magnetic and merely turn round when the magnetizing force is applied which represent these actions to some extent, but not so closely as might be desired. However it is probable that the theory might be so modified as to agree with experiment.

2.



The second method of studying the tables is to plot them with the values of Q as abscissas and μ as ordinates. In this way we obtain a curve which has some remarkable properties and which has the advantage over the other kind inasmuch as it is of finite dimensions and from it we can obtain the maximum of magnetization easily by a simple measurement. In the figure 2 have given plots of tables I and V, the larger being the curve of iron and the smaller of nickel, the horizontal scale of both being the same, but the vertical scale of nickel being several times larger than that of iron. On plotting a table in this way and then drawing lines across the curve parallel to the axis of Q and bisecting them we notice the strange fact that the center points always fall very exactly on a straight line, which is therefore a diameter of the curve. All the substances which I have tried, steel, iron and nickel, obey this law, and I hope soon to make it general by experiments on cobalt. I have obtained an empirical equation to express this curve, which is of the form

$$\mu = \mathrm{B}\sin\left(\frac{\mathrm{Q}+b\mu+\mathrm{H}}{\mathrm{D}}\right),$$

in which B, H, D, and b, are constants depending on the kin and quality of the metal used. B is the maximum value of

* Treatise on Electricity and Magnetism, Arts. 443–4–5.

and gives the height of the curve (see figure); b establishes the inclination of the diameter TS; H is the line P o and D depends upon the distance PR. The following equation, adapted to degrees and fractions of a degree, is the equation from which the values of μ in table I were calculated:

$$\mu = 2475 \cdot \sin\left(\frac{Q + 10{\cdot}94\mu + 5000}{1000 \cdot}\right).$$

The relation between Q and M is readily obtained from this equation by substituting the value of μ, which is $\frac{Q}{4\pi M}$. These equations can in general be solved only by successive approximations, but in the first case where Q and μ are involved, we may solve with reference to Q. This formula has been tried for all the tables, giving the proper values to the constants, and agrees with them all very exactly.

On plotting any table in this way and measuring the distance o R, we have the maximum of magnetization.

I have deduced the constants in the formula for no less than twelve cases of iron and two of nickel, and find them to vary between wide limits: the value of B, which is the maximum value of the permeability, varies between 5500 for the best Norway iron very carefully annealed and 330 for Stubs' steel of such temper as the wire is when bought, but of course this would be much less for hardened steel.

I have also obtained the maximum value of Q in many cases, and find it for good, but not pure, iron to be about 175,000 and for nickel 63,000; that is, the magnetization of iron can never exceed 175,000 times the unit magnetic field on the meter, gram, second, system, neither can nickel exceed 63,000 times. These can be reduced to the magnetic moment of a unit of volume by dividing by 4π and subtracting 1; they then become 13,920 and 5010 nearly.

We can also deduce from these quantities the greatest weight which an electro-magnet can sustain. Prof. Maxwell has given * a formula for the tension of the lines of force per square meter of section, which is $\frac{Q^2}{8\pi}$ absolute units of force, or

$$\frac{Q^2}{173\,240\,000} \text{ lbs. per sq. in.}$$

which gives 177 for Q = 175,000 and 22·9 for Q = 63,000. Hence we may conclude that the greatest weight which can be sustained by an electro-magnet with an infinite current is for iron 354lbs. per square inch of section, and for nickel 46 lbs.

* Treatise on Electricity and Magnetism, vol. ii, p. 256.

It is, of course, independent of the length of the iron bar forming the magnet and depends only on the section.

Joule* has made many experiments on the maximum sustaining-power of magnets, and has collected the following table, which I give complete, except that I have replaced the result with his large magnet by one obtained later.

Magnet belonging to	Least area of section in sq. inches.	Weight sustained in lbs.	Weight sustained ÷ least area.	Q.
Mr. Joule, 1	10·00	2775·	277.	154700
Mr. Joule, 2	·196	49·	250·	147000
Mr. Joule, 3	·0436	12·	275·	154100
Mr. Joule, 4	·0012	·202	162·	118300
Mr. Nesbit,	4·5	1428·	317·	165500
Prof. Henry,	3·94	750·	190·	128200
Mr. Sturgeon,	·196	50·	255·	148500

It is seen that these are all below my estimate, as they should be. For comparison, I have added a column giving the values of Q, which would give the sustaining power observed: it is seen that they range about as high as those that I have *actually* obtained, thus giving an experimental proof that my estimate of 354 lbs. cannot be far from correct, and illustrating the beauty of the absolute system of electrical measurement by which, from the simple deflection of a galvanometer-needle, we are able to predict how much an electro-magnet will sustain without actually trying the experiment. The experiments also give the data for other calculations of great interest.

I have in this paper confined myself principally to the discussion of Q, but I hope at some future time to resume the discussion of the results as obtained for T and P.†

* Phil. Mag., 1851.

† In order to facilitate the reduction of my units to others, I here give the relation between the letters used by me and those used in Prof. Maxwell's Treatise on Electricity and Magnetism.

Q in this paper = $\mathfrak{B}$ (Maxwell) = magnetic induction. Art. 605.

Q′ " " = $\mathfrak{A}$ " = surface integral of magnetic induction. Art. 402.

4πM " " = $\mathfrak{H}$ " = magnetic force. Art. 605.

$\frac{Q}{4\pi} - 1$ " " = $\mathfrak{k}$ " = intensity of magnetization. Art. 605.

μ, k, and κ, are the same as in Maxwell's Treatise.

I have throughout spoken of lines of force, &c. in the sense used by Faraday; for a note on the interpretation of these terms see Maxwell's Treatise on Electricity and Magnetism, Art. 404.

ART. XLVII.—*On the Geology of Western Wyoming;* by THEO. B. COMSTOCK, B.S., Geologist of the Northwestern Wyoming Expedition, 1873.

THE Northwestern Wyoming expedition sent out in June last, by General Ord, charged with the exploration of the headwaters of the several rivers having their sources in the northwestern corner of Wyoming Territory, having returned from the work in the field, it is proper to make known, in a general way, the results of their explorations. The work of preparing the reports for publication has already begun, but it will require several months for the complete elaboration of the material collected for study.

It is proposed, in this paper, to give a simple resumé of the results of the field labors of the writer, with such references to the general results of the expedition as may be necessary by way of explanation. It will be distinctly understood, however, that the writer is alone responsible for all statements herein made concerning the labors of others as well as his own.

The working corps was organized as follows:

Captain W. A. JONES, U. S. Engineers, Commander.
2d Lieut. S. E. BLUNT, 13th U. S. Infantry, Astronomer.
Dr. HEISMAN, Ass't Surgeon, U. S. Army, Surgeon.
Dr. C. C. PARRY, Botanist and Meteorologist.
Prof. THEO. B. COMSTOCK, Geologist.
LOUIS VON FROBEN, Chief Topographer.
GEORGE C. HITT, Assistant to the Astronomer.
J. D. PUTNAM, Assistant to the Meteorologist.
PAUL LE HARDY, FRED. W. BOND, CECIL GABBETT, Assistants to the Topographer.
CHAS. T. CREARY, FRED. MILLARD, GEORGE JEWETT, General Assistants.

The members of the expedition left Omaha, June 2d, 1873, proceeding, via Union Pacific Railroad, to Fort Bridger, Wyoming Territory, at which point the labors of the scientific corps were begun. While awaiting preparations to move, I visited the Uintah Mts., in order to obtain some idea of the great Tertiary Lake basin through which we were intending to pass on our march northward,* and, if possible, to make the ascent of Gilbert's Peak. Mr. J. D. Putnam accompanied me with a mercurial barometer. With great difficulty we succeeded in reaching Henry's Fork, but found it impassable, running a perfect torrent, and so rapidly rising from the melting of the snow that we were driven out of the narrow valley by the overflow. The sections exposed, however, were sufficient to show the structure of this rim (the southern) of the Green River basin, which is not materially different from that of the Rocky Mountain

*See paper by Prof. O. C. Marsh, "On the Geology of the Eastern Uintah Mts." Amer. Jour. Science, III, vol. i, March, 1871.

system in general, except that the rocks of Mesozoic age cover the older formations to a greater extent than common. Overlying these, with a very slight dip, and jutting against the northern slope of the Uintahs, are the immense fresh water Tertiary deposits, now eroded to an almost incredible extent over the whole basin, which has an area of over 20,000 square miles. The junction of these beds with the older deposits is much obscured by an accumulation of drift material, but at several points along Henry's Fork of Green River, rocks underlying conformably the red sandstones, which I have referred to the Mesozoic, are seen.* The surface Tertiary beds of the southern and western portion of the basin appear to belong to Hayden's "Bridger Group," of Upper Miocene age,† being composed of dull-colored clays with beds of sandstones of considerable thickness, usually brownish, or dull yellow or gray, and having more or less of a concretionary structure.

Upon our return to Fort Bridger, the train moved northeast through South Pass to Camp Stambaugh. Along our route the Bridger group is exposed at the surface over a considerable extent of country northward and eastward from Fort Bridger, as far as Little Sandy Creek and beyond, forming the top layers of numerous isolated "buttes,"‡ giving them, when the clays predominate, the so-called *grizzly* aspect alluded to by Prof. Marsh.§ It is impossible, without more extended study, to *define* the lower limit of the Bridger group, but it passes gradually into a series of marls and limestones containing quantities of the remains of fresh water forms of life, with laminated layers literally filled with the remains of land plants. The famous "petrified fish bed," well exposed near Green River station, Union Pacific Railroad, belongs to this group, which, following Hayden, is called the Green River group. The buttes of this formation not crowned by a considerable thickness of the beds of the Bridger group, have not the grizzly appearance of the latter beds. The Green River beds are of Lower Miocene age,

* The red sandstones which I here refer to the Mesozoic are regarded by Marsh as of Cretaceous age, from the fact that "they have below them, farther down the stream, calcareous beds containing undoubted Jurassic fossils." (Marsh, this Journal, vol. i, March, 1871, p. 3.) The rocks which I noticed below the red sandstones are mainly laminated shales, abundantly ripple-marked, but containing no fossils that I was able to detect.

† "Geol. Survey of Wyoming," etc., by F. V. Hayden, 1870: Washington, 1872, pp. 55, 58.

‡ The term "butte" is used indiscriminately in the west to designate *all* isolated hillocks or eminences standing out prominently in the topography of a country, if the breadth does not exceed the height. In this paper, its use is restricted to *hills of erosion* in stratified rocks.

§ Those *buttes* which are largely composed of indurated clays are scored by numerous water channels or gullies, which run down their sides in a branching and radiating manner, causing, at a little distance, that peculiar shaggy appearance which has given them the name of "Grizzly Buttes."

and overlie conformably a thick deposit of sandstones and arenaceous rocks, which, though varying sufficiently to admit of division into minor groups, are best considered here under the comprehensive name of Eocene. Careful notes and collections have been made, which will enable me to classify these beds.

On the western slope of the Wind River Mountains, near South Pass, no signs of strata older than the Tertiary were discovered, but the evidence of powerful glacial action is abundant. Several comparatively low ridges or folds in the metamorphic rocks are passed over before reaching the main divide or axis of the range, beyond which the original structure is very largely obliterated by various kinds of erosion, and the filling in of the gravels and finer material of the drift. In the metamorphic schists and gneissoid slates of the Wind River Mountain nucleus, occur the auriferous quartz veins of the Sweetwater mines. Several days were spent in company with Capt. Jones in a somewhat detailed survey of the various mines in this vicinity, including a study of the veins in the neighborhood of Miner's Delight, beyond Camp Stambaugh. The gold of this region occurs in thick veins of impure quartz, associated with considerable silver, and more or less of iron pyrites. The greater portion is disseminated through the vein rock, but it not unfrequently is found native in cavities in the quartz, in fair sized nuggets.

From Camp Stambaugh the route lay northwest along the eastern base of the Wind River Mountains, as far as Camp Brown on the Little Wind River, thence across the Wind River Valley, over the Owl Creek Mountains, and across the valley of Owl Creek above the junction of its forks.

The geology of the eastern slope of the Wind River Mountains is quite simple, affording many fine sections exposing representatives of all of the great groups of sedimentary rocks, from the Silurian to the Cretaceous inclusive, conformable to each other, and dipping away from the underlying metamorphic rocks at an angle of 20°. On one of my trips into these mountains I discovered limestone strata of Silurian age, containing remains of Trilobites and Corals not yet determined, but which for the present I refer to the Potsdam Period. The Devonian strata are best represented by the Oriskany sandstone, containing quite abundant remains of *Spirifer arenosus*. The rocks belonging to the Carboniferous age would seem to be almost wholly Subcarboniferous, containing *Orthis Michelini*, *Lithostrotion Canadense*, a *Chonetes*, and a species of *Poteriocrinus?*. Other fossils collected, but undetermined, may prove the existence of later Carboniferous strata, however.

A problem of no little difficulty is the definition of the lines of junction of the Triassic with the Jurassic, and the Jurassic with

the Cretaceous. It is sufficient, however, for our present purpose, to state that the Triassic beds are represented by thick deposits of bright red sandstones, which are overlaid by lighter, or buff-colored sandstones of Jurassic age, and these again by sandstones and shales, with interstratified brown lignite beds, and occasional seams of coal, which, I cannot doubt, are of Cretaceous age.* Special attention has been given to this question, and it is hoped that ample material has been collected for its solution.

An interesting and peculiar fold in the sedimentary strata, making a parallel ridge to the mountains, causes a kind of trough to be formed, with a double exposure of the Mesozoic beds, thus greatly aiding human industry by bringing to the surface again the valuable deposits of gypsum, which occur abundantly in the Triassic rocks, as well as the more or less valuable coal deposits before alluded to. To this folding of the strata may also be traced another economically important result to this highly favored section. I refer to the existence of hot and cold sulphur springs, and oil springs producing by evaporation a valuable asphaltum. I shall have more to say of this and other features of the Wind River Valley on some future occasion.

Fine exposures of the Jurassic and Cretaceous rocks are seen in the outlying ridges of the Owl Creek Mountain system, with numerous fossils. A species of the Lamellibranch genus *Gryphæa* is remarkably abundant in the Jurassic limestones, which are here nearly vertical.

The fresh water Tertiary beds jut against the older deposits almost exactly as those of the Green River basin overlie the red sandstones of the Uintah Mountains, and like them they are nearly horizontal. In composition, they are buff sandstones and conglomerates, with a few beds of marls and limestones; the irregular but excessive erosion to which they have been subjected has left them so poorly exposed along our route as to make their study quite difficult. Enough material has, however, been gathered to determine their age, and probably to divide these beds into groups. I can only say at present, that the evidence seems to point toward a division of the series into at least two groups, the latter being characterized by the occurrence of shore deposits of soft sandstones and conglomerates in beds of considerable thickness, which contain scarcely any fossils, and which it may not be hazardous to regard as Upper Eocene. The upper group would then be made to include a considerable thickness of interstratified marls and laminated calcareous beds rich in the remains of land plants, apparently of Lower Miocene age.

* Dr. Hayden, "Geol. Surv. of Wyoming," 1870; "Geol. Surv. of Montana," 1871, refers coal beds of the same horizon to the "Lower Tertiary or Upper Cretaceous."

The metamorphic nucleus of the Owl Creek range is not well exposed, being covered, except in a few isolated localities, by the early sedimentary rocks.

Continuing our march, we crossed the three forks of Owl Creek, passing through an excessively rugged country, affording numerous exposures of the various sedimentary strata, as well as interesting studies in dynamical geology. I can scarcely imagine a more favorable locality for the study of surface geology than this section between the Owl Creek Mts. and the Stinking Water River. I have said nothing of the magnificent terraces, the enormous deposits of the drift, the cañons and gorges cut by the streams, nor of the no less interesting proofs of the power of the wind; and yet these are but the half of the agencies whose actions are here so plainly indicated.

From Grey Bull River to the Stinking Water Valley our course lay through a less rugged country until we reached an eminence which gave us a view of some of the minor tributaries of the South Fork, when we were obliged to descend by a very steep trail to the valley below. From this point our march was comparatively easy to the north branch of the South Fork, which we ascended to its source in the mountains east of Yellowstone Lake. Passing through a narrow pass in this range, we descended on the other side to the lake, then marched down the Yellowstone River to the bridge, and crossed, a portion of the party visiting the hot springs of Gardiner's River. From the bridge we passed up the river to the falls, from which point we struck across westward, over the divide to the East Fork of Madison River, thence through the Lower and Upper Geyser Basins of Firehole River. Ascending the Firehole River, we then crossed the divide to Yellowstone Lake at the Sonthwest extremity, following pretty closely its shore until we reached the Upper Yellowstone River, which we ascended to the "Two Ocean Water." This is a mountain stream which flows down into a little valley, where it curiously splits into two rivulets, which shed their water, the one into the Pacific Ocean by way of the Snake and Columbia Rivers, the other into the Gulf of Mexico via the Yellowstone, Missouri, and Mississippi. Descending for a short distance one of the tributaries of Snake River, our Indian guide *To-goh-te* led us through an easy pass to the head-waters of Wind River, down which we marched, returning to Camp Brown to disband.

The head-waters of the Stinking Water,* rising in the very

* It is to be regretted that many of the geographical names in the West are so often repeated, rendering it difficult to distinguish between localities, without tedious explanation. For instance, the names Muddy, Sandy, Clear, Dry, Sage,

rugged range of volcanic origin east of the Yellowstone Basin, have cut narrow cañons through this material for a distance of more than seventy-five miles, affording rare opportunities for the study of the effects of subterranean forces. The great mass of the range is made up of a volcanic breccia, with numerous dykes and veins of porphyrite, and hornblendic trachyte. This material in some places covers unconformably the underlying aqueous rocks, thus proving its age, as would seem probable, to be later than the Cretaceous. But there is evidence, again, which points to outflows at a much earlier date: and, while there are proofs of eruptions between the close of the Cretaceous and the deposition of the Pliocene beds, there is also conclusive evidence of the outpouring of igneous material upon these same beds of Pliocene age. I do not claim that I have been able to unravel the whole of this intricate problem, but I am confident that sufficient material has been collected for a more complete elucidation of this subject than it would have been possible to reach without a survey of the section traversed during the past summer. I am extremely loth to commit myself to any decided opinion, however, until I can make a more complete study of notes and specimens.

The minor volcanic phenomena of geysers, solfataras, and hot springs, so abundantly manifested within the area reserved for the National Park, have received their due share of attention, and a large quantity of material has been collected for study. This leads me to speak of another important branch of geology, too frequently overlooked, I think, in our surveys, and yet a department of the science, as interesting as it is important, i. e., chemical geology. Throughout the trip, I have taken special pains to observe, and collect as much material as possible in this department, and I believe that I have succeeded in obtaining much valuable information by this means, which would otherwise have escaped my notice. Some interesting facts concerning the formation of chalcedony and the moss agate, the deposition of the so-called "alkali," and the silicification of the immense quantities of "petrified" wood in this region, have thus been collected, besides a mass of material concerning the erosion and weathering of the rocks, and the forces affecting or affected by the physical geography of the country. One fact, which I consider of much importance, is the abundance of ozone in the atmosphere, to which I trace much of the external reddening of many of the yellow and brownish sandstones containing iron.

Cottonwood, Beaver, etc., are each used to designate several streams within a comparatively small area. It is therefore necessary to note that the Stinking Water River to which I refer in this paper, is the important tributary of the Big Horn (Lower Wind) River, by that name, and *not* the tributary of Jefferson River, which bears the same name.

The comparatively recent discoveries of immense deposits of coal in the Rocky Mountains makes the study of its modes of occurrence, its quality, and the conditions of its formation, a subject of great economic and scientific interest, which it is desired to present in the most satisfactory manner. For this purpose, specimens from all of the important outcrops along our route have been carefully obtained, and minutely recorded. Having some opportunities for observation and study of the language, manners and customs of Washakie's band of Shoshones or Snake Indians, I was enabled to collect also a few notes, which may serve, in a small way, to assist in preserving some records of their peculiarities, ere the onward march of civilization shall forever, by conquest or assimilation, destroy their *Indian* charateristics. All of these subjects, when properly elaborated, will be incorporated in my report to the chief of the expedition, to be given to the public in due time.

In conclusion, my thanks are due to each member of the party, including the officers of our escort (Company I, 2nd U. S. Calvary) and to the officers and others at Fort Bridger, Camps Stambaugh, Camp Brown and Fort Ellis, to whom I am indebted for kindnesses too numerous for recital.

Cherishing the hope that my humble labors in the cause of science may prove of some value to others, I leave this resumé in the hands of my fellow-workers for their verdict.

Cleveland, O., Oct. 25, 1873.

Art. XLVIII—*The Number of Classes of Vertebrates and their Mutual Relations*; by Prof. Theodore Gill.

(Abstract of a Communication to the National Academy of Sciences made Oct. 29, 1873.)

The mind, untrained in scientific logic, in its generalizations respecting the animal kingdom, if we may judge by the vague ideas elicited by inquiry and by the history of science, instinctively associates its subjects into groups determined by the nature of their habitat; and hence we have had the vertebrates differentiated into (1) those especially adapted for progression on land (Quadrupeds); (2) those especially fitted for progression through the air (Birds); and (3) those adapted for life in the water (Fishes); while the residue, not readily combinable with either of those classes, are tacitly overlooked, or, as the Serpents, annexed as a kind of appendix to the Quadrupeds, because they most resemble certain of those animals—the lizards. It was, therefore, a great advance when Linnæus established a peculiar class (Mammalia) for the typical viviparous quadrupeds

and the whales, and thus for the first time subordinated habitat and adaptation therefor to structure. While at the present day, the ancient ideas have almost entirely disappeared from the system of nature so far as regards the terrestrial vertebrates, they are still to a great extent prevalent in the appreciation of the relations of the aquatic ones. For those vertebrates confounded by most naturalists under the name of Fishes, are very dissimilar among themselves, and so much so even that the differences are more marked and radical than those between any of the superior classes of the branch. If, indeed, considerations of differences of structure are to guide us in the appreciation of the relations and subordination of animals, the current classification must be entirely changed, and the subordination of the highest groups, first suggested by Häckel, should be adopted with some modifications, while as respects the combination of the "higher" or more specialized classes into superior groups, other principles should guide. One of the chief points to be reconsidered is the association of the Batrachians with Fishes rather than with the true reptiles. Although no distinction may be possible between the first two when the class of Fishes has the wide range generally allowed, there is no difficulty in their discrimination with the limits here to be assigned to them. We may then group the classes as follows:

On the one hand is *Branchiostoma* or *Amphioxus*, distinguished by the extension of the notochord (which is, of course, persistent) to the anterior end of the vertebral column, the attenuation of the spinal cord forward and its simple structure, the absence of auditory organs, the simple tubular structure of the heart, and the development of the liver simply as a diverticulum of the intestine. This type is called by Häckel the *Subphylum Leptocardia* or *Acrania*.

On the other hand are all the other Vertebrates, which agree in the termination of the notochord behind the pituitary fossa, the enlargement of the spinal cord forward into a brain, the development of auditory organs, the division of the heart into (two to four) chambers, which in part (one or two) specially receive the blood, and in part (one or two) specially distribute it to the body again, and the differentiation of the liver as an independent and highly specialized organ. This group is named by Häckel the *Subphylum Pachycardia* or *Craniota*.

The numerous forms belonging to the last "subphylum" are also divisible into two great groups.

In one, the skull has no cincture girdling the mouth and consequently no lower jaw, there are no pectoral members or scapular girdle, and there is but one nasal sac, which has a median external aperture. To this section belong the Lampreys and Hags, the representatives of the class of *Marsipobranchs*.

In the other, the skull has a cincture surrounding the mouth, its inferior portion being specialized as a lower jaw; they have (archetypically at least) a pectoral member and a shoulder-girdle developed; and there are two nasal sacs, each having an olfactory nerve distributed to an external aperture. These Vertebrates are again divisible into three groups or superclasses.

1. In the first (*Lyrifera*) the shoulder-girdle forms a lyriform or furcular-shaped apparatus, the scapulæ and their adjuncts of both sides being connected together below along the median line, and an air bladder (sometimes lung-like) is attypically developed (sometimes, however, atrophied) and (1) either connects with the œsophagus by a single duct or (2) is entirely closed. To this superclass belong the classes of Fishes and Elasmobranchiates.

2. In the second (*Quadratifera*), the shoulder-girdle is represented by the scapulæ and their appendages, which are limited to the respective sides, a sternum is differentiated, and instead of an air bladder are two lungs, each with a special canal, which communicate with the pharynx. The lower jaw is compound and is articulated with the skull by the intervention of a special bone—the os quadratum. In this superclass belong the Batrachians, the Reptiles, and the Birds; the last two forming the group *Sauropsida*.

3. In the third (*Malleifera*), the shoulder-girdle is represented by composite scapulæ, limited to the sides or back; a sternum is developed; respiration is entirely effected by highly specialized lungs communicating with a common trachea, and the lower jaw is composed of simple rami, and articulated directly with the skull, the os quadratum of the other vertebrates being converted into one of the auditory ossicles (the malleus). This superclass is represented by a single class—the Mammals.

The more these groups are studied in all their relations the more natural do they appear.

As to other questions, that is, whether the true Fishes and Selachians are not separate classes, there is much to be said on both sides, and perhaps the arguments in favor of the class value of the Selachians may be even more weighty than those against them. If, however, the Birds and Reptiles are differentiated as distinct classes, similar rank can scarcely be consistently withheld from the Fishes and Elasmobranchiates. If I have heretofore hesitated, it is because of Dr. Günther's very adverse views.

Without prejudice to the reconsideration of the question as to the systematic value of the group of Selachians or Elasmobranchiates, the classes of Vertebrates may then be distributed, in a descending series, as follows:—

Branch VERTEBRATA.
A. Sub-branch CRANIOTA.
Superclass MALLEIFERA.
I. Class Mammalia.
Superclass QUADRATIFERA.
(Sauropsida.)
II. Class Aves.
III. Class Reptilia.
(Batrachopsida).
IV. Class Batrachia.
Superclass LYRIFERA.
V. Class Pisces.
VI. Elasmobranchiates.
Superclass MONORRHINA.
VII. Class Marsipobranchia.
B. Sub-branch ACRANIA.
VIII. Class Leptocardia.

The most nearly related pair of classes are those of Birds and Reptiles, and pre-eminently the most homogeneous is that of Birds, all the living representatives of which seem to be members of a single order (which may be distinguished by the name Eurhipidura), and at most divisible into two suborders—the Carinatæ and the Ratitæ. Other orders are represented by extinct types, viz.: Saururæ, and (if the vertebræ are peculiar to the group) Odontornithes.

ART. XLIX.—*Brief Contributions to Zoölogy, from the Museum of Yale College.* No. XXV. *Results of recent Dredging Expeditions on the Coast of New England. No.* 3; by A. E. VERRILL.

THE investigations of the marine life and physical conditions of the waters of our coast, under the auspices of the U. S. Commissioner of Fisheries, Prof. S. F. Baird, was continued during the past season, under even more favorable circumstances than during the two previous years. This year the headquarters were established at Peak's Island, at the entrance of the harbor of Portland, Maine, and about four miles from the city. This proved to be a very favorable locality, on account of its central position, allowing us to dredge in all parts of Casco Bay and the connected bays and fiords, and to visit any of the numerous islands for which Casco Bay is so famous, without too great loss of time; and to take advantage of favorable weather for longer trips to the deeper waters outside the bay. The littoral animals of the island itself, owing to the diversity of the shores and purity of the water, also proved to be numerous and interesting.

The scientific party was quite large during the greater part of the time while active operations were carried on.

The fishes and the investigations more immediately connected with the fisheries were attended to by Prof. Baird, aided by his secretary, Mr. Rockwell, Prof. Theodore Gill, Dr. Edw. Palmer, Mr. G. Brown Goode, Mr. Spencer Biddle and others. The dredging operations, the examination of the food of fishes, and all investigations concerning the invertebrate animals generally, were in charge of the writer and Mr. S. I. Smith, aided by Prof. Wm. N. Rice and Mr. Goode, of Wesleyan University; Prof. J. E. Todd, of Tabor College, Iowa; Prof. H. E. Nelson, of Ohio Wesleyan University; Mr. J. H. Emerton, Salem, Mass.; Mr. J. K. Thacher, of Yale College; Mr. Franklin Benner, Astoria, N. Y.; and for a short time by Dr. P. P. Carpenter, of Montreal; Dr. Holder, of New York, and several others.

Much of the success of the expedition was due to the interest taken in such scientific researches by Secretary Robeson, who caused a small U. S. steamer, the "Blue-light," to be specially fitted out for our dredging operations, under Commander L. C. Beardsley, U. S. N. This steamer was provided with a steam windlass for hoisting the dredges and trawls, and with other conveniences, which greatly facilitated our operations, and enabled us to make much longer excursions to the outer waters, and to do much more work during the summer, than would otherwise have been possible. Captain Beardsley took great interest in our investigations and did all in his power to aid us in various ways. His constant endeavor was to make the steamer as useful as possible to us. Our thanks are also due to Mr. Cook, the executive officer, and to all the other officers and men for the hearty good-will with which they coöperated in our work and executed all our plans.

Ample wharf privileges were found at "Trefethen's Landing," and a building upon the wharf was speedily converted into a rather rude but comfortable laboratory. An excellent set of apparatus was provided by the Fish Commission, including a large assortment of dredges, rake-dredges, tangles, trawls, towing-nets, seines, sieves of various kinds, and all other kinds of apparatus and improvements which our past experience had proved useful or desirable. Sets of the apparatus such as were used by the English expeditions, on the "Porcupine" and "Challenger," were also imported by Prof. Baird, but were not found to offer any advantages over those which we had used in previous years. The English "accumulator" we found no occasion to use in our work, for a simple "check-stop," devised by Capt. Beardsley, proved equally efficient and far more convenient and simple, as well as quite inexpensive.* This

* This arrangement and the dredges, tangles, trawls, rakes, and other apparatus used by us, were described and illustrated in several letters to the New York Tribune by Mr. Wyckoff, one of the editors, who spent some time with us at the island, and accompanied us on several excursions. These letters are brought together in the "Tribune Extra," No. 10, Scientific Series.

was found to answer every purpose in dredging or trawling at all depths down to 100 fathoms, and undoubtedly would do equally well at far greater depths. With a larger vessel, in heavy weather, or at very great depths, the rubber accumulator would doubtless prove advantageous, but it is quite superfluous for working in less than 500 fathoms, in moderate weather. Therefore, any party undertaking such dredgings as can be carried on with small vessels off our coast, need not encumber themselves with this expensive piece of apparatus, for which a few fathoms of small or weak rope, applied in the form of a "check-stop," may be substituted!

Deep-sea thermometers, water-bottles for obtaining samples of the bottom-waters, and other physical apparatus, were also provided and frequently used.

Mr. Emerton was employed during the two months of active work in making drawings of the more interesting new and rare animals, from life. These drawings are remarkably accurate and life-like, and number nearly three hundred. They constitute one of the most valuable results of the expedition. As Mr. Emerton had drawn large numbers of our common marine animals for us during the two previous years, a considerable portion of his time was this year devoted to the free-swimming larval stages of crustacea, etc., and to the smaller and less known species in various classes. The soft parts of many species of mollusks were also well figured.

In consequence of the liberal coöperation of Prof. Pierce, superintendent of the U. S. Coast Survey, and other officers of the Survey, the U. S. Coast Survey steamer Bache was despatched, during the month of September, on several dredging expeditions to the deeper waters and distant banks off the coast of Maine, which we could not well reach with the "Blue-light." The dredges and other apparatus necessary for this work were provided by Prof. Baird, and the dredging on the Bache was under the superintendence of Dr. A. S. Packard, of the Peabody Academy of Science, Salem, Mass., aided by Mr. Caleb Cooke, also of the Peabody Academy. They were very successful in these investigations, and made several collections of great interest. The results of their work will be referred to in another article.

One of the most interesting regions examined was in the deeper waters outside of Casco Bay, 15 to 30 miles southeast from Cape Elizabeth. To this region we made several excursions, and dredged at depths varying from 40 to 95 fathoms, the depth gradually increasing with the distance from the shore. In these localities the bottom was generally of soft mud, with more or less numerous, scattered boulders. On one occasion we brought up in the trawl from 65 fathoms an angular boulder,

estimated to weigh over 500 lbs. These boulders were probably transported from the adjacent coast by shore-ice in spring. They were usually covered with sponges, bryozoa, ascidians, hydroids, *Terebratulina*, etc. The bottom temperature of these waters was remarkably low, varying from 36° to 40° F., while the surface was usually between 55° and 65°, or even higher. The temperatures obtained here are quite as low as those that we obtained in the deeper parts of the Bay of Fundy last year, and the fauna proved to be correspondingly arctic in character, and agrees pretty closely with that at the mouth of the Bay of Fundy, and also with the dredgings made last year, in 85 to 150 fathoms, near St. George's Banks. In fact, these three regions may be regarded as distant parts of one great basin, referred to in a former article as "Saint George's Gulf," and this region is throughout its whole extent bathed in cold water of nearly uniform temperature at corresponding depths. The deepest parts of this gulf seldom exceed 150 fathoms, and are perhaps nowhere more than 200 fathoms. Whether the nearly ice-cold water filling the deeper parts of this cold-area can be regarded as constituting a definite current, or offshoot from the great arctic current, flowing southward along our coast in deep water off shore, or whether it is a portion of the great body of cold water filling the ocean basin at great depths, which is brought into this partially closed basin by the powerful tidal currents, is still uncertain. But it is important to have established the fact that this body of cold water approaches so closely to the coast of Maine as to manifest itself most distinctly within 12 or 15 miles of Cape Elizabeth, both by its highly arctic fauna and its icy temperature, even in midsummer. Moreover, there can be no doubt but that the constant admixture of this cold bottom-water with the warmer surface-waters, by means of the strong tides and local wind currents, causes the remarkably low temperatures observed in the shallow waters of these* shores, and even in the smaller bays and harbors along the entire eastern and northern coast of New England. It is also evident that a strong wind blowing from the shore for some time will have the effect to cause an ascending current of cold water along the submerged slope of the shore, to supply the place of the surface-water driven seaward by the wind; while an easterly wind will force the warmer surface-water toward the shore, and cause a descending current along the slope, partially forcing the cold water away from the shallows. Our observations, both in Vinyard Sound and Casco Bay, show that such an action does take place, and that the

* The temperature of the bottom-waters in the deeper channels among the islands, in 15 to 25 fathoms, was usually from 42° to 50° F.; while the surface was usually between 55° and 65° in July and August.

temperature of the water near the shore is rapidly lowered by a westerly or off-shore wind, and is as quickly raised by an easterly wind, independently of the temperature of the air.* But the effect is often somewhat masked, in summer, by reason of the much higher temperature of the westerly winds, which quickly warm the water close to the surface. Observations made early in the morning, before the effect of the direct heat of the sun becomes apparent, are the best for detecting the influence of tidal and wind currents.

The following are some of the species obtained in these localities in 50 to 95 fathoms: of Fishes, *Raia lævis*, *Sebastes viviparus*, *Pomatopsetta dentata;* of Crustacea, *Hyas coarctata*, *Pandalus borealis* of large size, *P. annulicornis*, *Sabinea septemcarinata*, *Hippolyte spina*, *H. Fabricii*, *Eupagurus Krogeri*, *Mysis*, (?) new species, *Pranïza cerina*, *Asselodes alba*, *Haploops*, sp.; *Nymphon giganteum;* of Annelids, *Aphrodite aculeata*, *Nychia cirrosa*, *Pholoë minuta*, *Ninoë nigripes* V., *Nothria opalina* V., *Gattiola*, sp.; *Sternaspis fossor*, *Goniada*, sp.; *Pista cristata*, *Terebellides Stroëmi*, *Ampharete gracilis*, *Melinna cristata*, *Amphitrite Grœnlandica*, *A. cirrata*, *A. Johnstoni*, *Maldane Sarsii*, *Nicomache lumbricalis*, *Vermilia serrula*, *Potamilla oculifera*, *Arenia*, new species, *Scalibregma inflatum*, *Anthostoma acutum* V., *Chætozone setosa*, *Ammotrypane fimbriata*, *Phascolosoma tubicola* V., *P. cœmentarium*, *Chætoderma lucida;* of Nemerteans, *Meckelia lurida* V., *Nemertis affinis*, and a gigantic species 8 feet long, belonging to a new genus;† of Mollusca, *Octopus Bairdii* V. from 68 fathoms, *Neptunea curta* (*Islandica* Gould), *N. pygmæa*,‡ *Aporrhais occidentalis*, *Turritella erosa*, *Lepeta cœca*,

* See the Report of the U. S. Fish Commission for 1871, p. 436, for a fuller discussion of this subject by the writer. Rev. J. W. Chickering also informs me that he has made series of observations at Hampton Beach, N. H., which establish such a coincidence. The change sometimes amounts to 10° F. in a few hours.

† *Macronemertes gigantea* Verrill. Body much elongated, subterete, a little depressed, thickest anteriorly, gradually tapering posteriorly, becoming very slender toward the end. Integument very soft, secreting a large quantity of mucus. Head not distinct from body, obtusely rounded in front, with a terminal pore; upper surface with two longitudinal fossæ; below with two rather indistinct transverse grooves, or fossæ, in advance of the mouth. Ocelli numerous, arranged in six clusters; a pair of large clusters on the anterior lateral border of the head; a pair of smaller lateral clusters farther back; and a pair of small clusters on the dorsal surface, between the longitudinal fossæ. Color, when living, bright orange-red above, flesh-color below. Length, about 8 feet, in extension; diameter, anteriorly, ·30 of an inch.

Off Cape Elizabeth, 68 fathoms, soft mud, Aug. 12.

‡ An examination of the dentition of this and the preceding species shows that they are true Buccinidæ, and quite different from the *Tritonium Islandicum* of Lovén (=*Fusus Berniciensis*, t. Jeffreys), which has been regarded as the type of *Sipho*. Our American shell, usually called *Islandicus*, but which has been named *Fusus curtus* by Jeffreys, is a genuine *Neptunea* closely allied to *N. despectus*, etc. The *pygmæa* differs considerably in its dentition from the typical forms of *Neptunea*, as well as in having a woolly epidermis, and ought to be separated as a distinct genus, or subgenus, which I have elsewhere described under the name of *Neptunella*. (See Report of U. S. Fish Commission, for 1871.)

Bela decussata, *Natica clausa*, *Schaphander puncto-striata* (of large size), *Entalis striolata*, *Dentalium occidentale*, *Cardium Islandicum*, *Astarte lens*, *A. elliptica* (one specimen), *Yoldia thraciformis* (large and fine, living), *Y. obesa*, *Y. sopotilla*, *Dacrydium vitreum*, *Macoma sabulosa*, *Nœra arctica* (large and fine), *Crenella decussata*, *C. glandula*, *Panopœa Norvegica*, *Pecten Islandicus* (several fine specimens), and many other northern shells, including one new species, allied to *Pleurotoma;* numerous Bryozoa, including *Flustra solidula* St., *Idmonea pruinosa*, *Caberea Ellisii*, etc.; many Ascidians, among which were *Glandula fibrosa* St., *Molgula retortiformis* V., *Eugyra pilularis* V., a large, new species of *Ascidia*, *Ciona tenella*, a fine new species of *Botryllus* of a deep purple color, etc.; of Echinoderms the most abundant species was the starfish, *Ctenodiscus crispatus*, of which we obtained about a thousand in one haul with the trawl, but *Ophioglypha Sarsii* and *O. robusta* were also abundant, *Hippasteria phrygiana* occurred twice, *Ophiocnida hispida*, *Schizaster fragilis*, *Thyone*, sp., *Molpadia borealis* (?) Sars, and several other interesting species also occurred; among the Polyps were *Cerianthus borealis* V., *Edwardsia farinacea* V., *E. sipunculoides*, *Urticina nodosa* Fabr. sp. (=? *Tealia digitata* Gosse),* *U. crassicornis*, *Bolocera Tuediæ* Gosse, very large and fine. The last species had not been known from the American coast before, except from a few detached tentacles dredged last year near St. George's Bank, and *U. nodosa* had not been previously found, except last year, when it was dredged by Mr. Smith east of St. George's Bank, in 430 fathoms, and by Mr. Whiteaves in the deeper parts of the Gulf of St. Lawrence. The specimens obtained this year are much larger, some of them being 6 inches high and 4 in diameter. Of Sponges, several very interesting species occurred; among them a large specimen, two feet broad, of the *Halichondria ventilabrum* of the earlier English writers; a species apparently belonging to the genus *Trichostemma* of G. O. Sars; and over twenty specimens of *Hyalonema longissimum* M. Sars, some of them of unusually large size; these were all obtained in 95 fathoms, about 30 miles east-southeast from Cape Elizabeth. This last species had not been dredged before on the American coast, with the exception of a single specimen dredged last year by Messrs. Smith and Harger, off St. George's Bank, in 430 fathoms. Mr. Whiteaves writes me that he has also dredged it in the Gulf of St. Lawrence this summer; and it was also subsequently obtained by Dr. Packard. A small specimen, belonging apparently to the genus *Holtenia*,

* It seems to me very doubtful whether the *Actinia digitata* of Müller was actually the species that commonly bears that name in recent European works. The description would apply better to the *Bolocera Tuediæ* of Gosse. The species referred to above is certainly the *A. nodosa* of Fabricius, who well described it in 1870, as from deep water off the Greenland coast.

was obtained with the *Hyalonema*, and also several other remarkable forms of sponges.

At another locality, about nine miles south-southeast from Seguin Island, in 75 fathoms, the same kind of bottom was found and the fauna was nearly identical with that described above. At this place the finest specimen yet observed of *Cerianthus borealis* V. was obtained in good condition, and was kept alive several days, until a colored drawing was made by Mr. Emerton. This specimen, in extension, was about 20 inches long, and the expanse of its tentacles was over six inches. The color of its body was deep olive-brown. This species was not discovered until last year, but it was met with at several different localities this year, and seems to be not uncommon on muddy bottoms in 20 to 100 fathoms, though seldom obtained of full size by the dredge, owing to its living deeply buried.

[To be continued.]

ART. L.—*Age of the Rocky Mountain Coal or Lignitic Formation.*

[As the age of the Lignitic formation of the Rocky Mountain region is far from decided, owing mainly to the contrary evidence afforded by the fossils of the vegetable and animal kingdoms, we propose to cite the arguments from different sources bearing on the subject, in order, if possible, to bring about agreement on this most important point in American geology. We here give first the conclusions of Mr. L. Lesquereux from the fossil Plants, published in Hayden's Report for 1872.—EDS.]

I. *Views of L. Lesquereux.*

Not a single leaf has as yet been found in our Eocene identical with a Cretaceous species. The genera especially represented in the Cretaceous are: *Sassafras*, *Credneria*, *Platanus*, *Salix*, *Liquidamber*, *Quercus*, *Populites*, *Liriodendron*, *Proteoides*, *Dombeiopsis*, *Acer*, and *Juglans*. We can dispose at once of the genus *Proteoides* on account of its as yet unknown affinity. It has been referred, as its name indicates, to Australian types, but from analogy I doubt if we may ascertain the presence of any of these types even in our oldest floras. Now, we have in our Cretaceous, as more easily recognized by their likeness to living species, leaves of *Sassafras* and of *Liriodendron*, the tulip-tree. If I should judge by the profusion of leaves of *Sassafras* which I have seen in the shale of the Dakota group, in the valley of the Saline River, and around Fort Harker, in Kansas, I would assert that more than two-thirds of the vegetation of this epoch did consist of species of this genus. But then, as now, however, related species appear to have lived in

groups, perhaps over limited areas; for at other localities Dr. Hayden found especially leaves of *Liriodendrons*, *Juglans*, and of *Platanus*, genera scarcely represented at Salina and Fort Harker. The groups may still differ elsewhere. The present remarks, however, must be limited to what is known, and *Sassafras* and *Liriodendron* have to be considered yet as the genera the most profusely represented in the flora of the Dakota group, even more, perhaps, than they are in that of the present time. The American Eocene has not yet shown any remains positively referable to these genera. I have described from specimens marked "*six miles above Spring Cañon*" the lower part of two leaves as, perhaps, referable each to one species of *Sassafras* and of *Liriodendron*; but such fragments cannot be taken into consideration for positive evidence in a comparison like this. They may represent leaves of different affinity. In the Miocene of Europe, per contra, the above genera are represented by a number of species. One of each, *Liriodendron* and *Sassafras*, are described from the Miocene flora of Greenland, and more from that of Germany and Italy.

The genus *Credneria*, or *Pterospermites*, appears to represent forms of leaves of a lost type. We have no representatives of it at our time, nor have any been seen in the Eocene. It has left its remains, however, in the Miocene of Greenland in four different species. Seeds, too, of undecided affinity are referred to *Pterospermites* from the Miocene of Oeningen. The Eocene species of *Platanus*, at least the three splendid species described by Dr. Newberry—*Platanus Haydenii*, *P. Raynoldsii*, *P. nobilis*—have no relation either to Miocene or Cretaceous types, which are mostly analogous to *Platanus aceroides*. This last species, however, like its relative, *P. Guillelmæ*, are as common in the upper American Eocene as the former ones are in the lower.—Of the species of *Salix* I have remarked already that they are more numerous in the Cretaceous than in the Eocene of ours. They re-appear more abundant in the Upper Tertiary groups of Green River.

Liquidambar, the sweet-gum, has one of its species in the Cretaceous. It has been described from one leaf only, but I have found recently a number of specimens of the same near Fort Harker. Our Eocene has nothing like it, while remains of one species, *Liquidambar Europeum*, are found over the whole Miocene of the old continent, together with a large number of forms as yet doubtfully referable to this genus. Our Cretaceous leaf is, perhaps, of this kind, on account of the entire divisions of its leaves; but this does not change its affinity to Miocene forms of Europe. Massalongo in his Flora-del-Senigalliese, has described and figured a *Liquidambar scarabellianum*, with the divisions of the leaves entire, a form much like that

of our Cretaceous species, only smaller; and Unger, in Flora of Sotska. has named *Platanus Sirii*, a leaf still more similar to ours. These leaves are considered by other authors as referable to the genus Acer. This does not make any difference. They represent a type of our Cretaceous and of the Miocene of Europe; as yet not seen in our Eocene. It is the same with *Acer* (maple) and *Quercus* (oak.) They are marked in our Cretaceous, the first by *Acer obtusilobum*, with characters of leaves seen again in the European Miocene, and at our present time on both continents; the second by a species related to some varieties of our chestnut-oak, and by two others comparable by the form of their entire leaves to our shingle-oak (*Quercus imbricaria* Michx.) Both these types are most common in the Miocene of Europe; but, like that of the Cretaceous maple, they have not as yet been observed in our Lignitic Eocene. The leaves which I have considered as of a *Juglans*, and which Heer refers to *Populous*, *P. Debeyana*, are of uncertain affinity. Their analogy has not yet been recognized out of the Cretaceous.

I could pursue to some length the examination of analogies of this kind, which may be considered as negative characters of the American Eocene. Besides establishing the remarkable relation of the American Cretaceous flora with the Miocene flora of Europe and the present flora of this continent, they serve to prove the disconnection of our Eocene flora from that of our Cretaceous, indicating therefore truly separate formations.

The positive characters of the same Lignitic flora more forcibly still elicit the same conclusion. From the beginning, in the examination of the sandstone of the Raton, I have recorded the great amount of fucoidal remains in this sandstone, as an essential character of its Eocene age. The irregularity of distribution of marine vegetable remains in the geological groups has been remarked by every paleontologist The oldest formation, the Silurian and the Devonian, have an abundance of them. The Carboniferous, except at its base, as also the Trias and the Permian, have scarcely any. In the Jurassic they begin to reappear, and their number increases upward to their maximum degree of distribution in the Eocene. Thus, while ten species only are known from the Cretaceous, thirty-five species have been already described from the Eocene of Europe. In our Cretaceous measures a single species has as yet been found, and this from the Fort Benton Group, near Fort Harker. It seems identical with *Fucoides digitatus* Brgt., but it is as yet uncertain to what section of marine vegetables this form is referable. I found it upon pieces of limestone covered with the species of large mollusks characteristic of this group. Referred by Bronguiart to the *Dictyotites*, by Geinitz to the *Zonarites*, by Schimper to the *Jeanpaulia* of the *Marsileaceæ*, by Schenck to

the *Ferns*, it is as yet impossible to mark its true affinity. It appears already in the Dias, as seen from Geinitz's description. Any how, it is of a character far different from any of those remarked in our Eocene fucoids. From its association with the mollusks of deep seas, it is clearly a deep marine species.

It is as yet too soon to enumerate, even approximately, the species of fucoids of the American Eocene. A few are described in this report. But by far the largest number is unknown, and will remain undescribed for a length of time, on account of the size and the inextricable embedding of the largest species with the sandstone. They have to be studied in place, represented in drawings, and their description can be made only from these representations. * * *

Coming to the examination of land vegetation, we are met at once by the appearance in our Eocene measures of a class of plants, giving evidence of the age of these measures, fully as conclusive as that of the fucoids. It is that of the palms, of the section of the Sabal. Scarcely any trace of these vegetables has been remarked in the Upper Cretaceous of Europe. There they become somewhat conspicuous in the Eocene, but their largest development is with the Miocene. With us they appear immediately above the great Eocene sandstone, or in connection with every bed of lignite formed within this sandstone, and show by the profusion of their remains the remarkable place which they have in the distribution of the flora of the Eocene epoch. Their fossil remains are most abundant in the Lignitic of Fort Union, where the largest leaves of Sabal have as yet been observed. At the Raton a good half of the specimens represent fragments of leaves, of petioles, of fruits of this species. At Golden they are found in the same proportion, and at Black Butte splendid specimens of palms are mixed with dicotyledonous leaves in the shale overlying the main coal; while the bed with Saurian bones and shells, about 150 feet higher in the measures, has Sabal leaves, too, less abundant, however, than the shale of the main coal. At Evanston, in the under sandstone, a quantity of fruits referable to palm has been found, and remains of the same kind are a marked feature of the scanty flora as yet known from the Arkansas and Colorado Lignitic formation. It might be argued that if some remains of palms have been found in connection with strata recognized as Cretaceous, these plants might as well be admitted as characteristic of Cretaceous age in our Lignitic. I do not know of a single case positively ascertained of palm remains in the Cretaceous. But even if we had any, their abundant distribution in the vegetation of our Eocene is sufficient proof that this class of plants had already acquired at that epoch a remarkable development. Its origin may be discovered later

by scarce remains in the Cretaceous; its preponderance in the vegetation of the Lignitic attests a more recent formation.*

The Tertiary groups of Europe are not as yet clearly limited. Many of the Lignitic strata which have furnished remains of fossil-plants to European paleontology were at first referred to the Eocene. Unger, for example, places in this formation the fossil plants of Radoboj, in Croatia, of Haering, in Tyrol, of Parshlung, of Sotzka, now referred to the Lower Miocene. Thus, too, the Bovey coal of England, which was considered contemporaneous to the Eocene of Wight, is now admitted as Miocene. The Tertiary deposits have been formed in basins of limited areas, and therefore the characters of their flora are not identical, even for contemporaneous deposits, on account of the diversity of the vegetation at various places and under various circumstances. This explains a difficulty of identification of strata which may be met perhaps in trying to circumscribe the upper limits of our Eocene. As yet, in this formation, homogeneity of the essential characters is recognized everywhere in its flora, and when it is compared with that of some locality positively ascertained as Eocene in Europe, it indicates, too, points of identity remarkable enough. Such is the flora of Mount Promina, where a fern found at Golden in splendid specimens is described by Professor Ettinghausen as *Sphenopteris eocenica*. In the same paper a species of *Myrica*, whose leaves appear to have been found in profusion at the same locality, is described and figured, indicating such affinity with leaves also very abundant at Black Butte, that it is as yet uncertain if the American form does not represent a mere variety of the same, differing only by the larger size of the leaves. We have at Golden, *Quercus angustiloba* Al. Br., described by Heer from the Bornstaedt Eocene, and in the flora of the same locality, as in that of Golden, a remarkable predominance of species of *Ficus* and of *Cinnamomum*, primitive types of the Tertiary of Europe. Some of these pass, with the Sabal species, into the Miocene; for, of course, the Tertiary formations, as land formations, removed from the influence of prolonged submersion in deep marine water, have, like the

* Vegetable paleontology has not any more recent and more positive records on this subject than those furnished by Schimper (Veget. Pal., vol. ii, 1871). This work describes twenty-four species of palms (fossil) in the three genera *Chamaerops*, *Sabal*, and *Flabellaria*, twelve of which are from the Miocene, ten from the Eocene, and two, *Flabellaria longirachis* Ung., and *F. chamæropifolia* Göpp, from strata considered as Cretaceous. Of these two species, Schimper says that the first, from the length of its rachis, is evidently a type of a peculiar genus, and that the other, whose rachis is unknown, cannot, on that account, be positively referred to any type. The author still describes twenty-two species of palms in other genera, all from the Tertiary, mostly Eocene, and twenty-three known from stems only, and these, too, all Tertiary. Admitting all the references as exact, this makes sixty-seven species of palms described from the Tertiary, and two from the Cretaceous.

Carboniferous, a permanence of the types of their flora, marked by a number of species identical in the groups even of the more remote stations. This answers the observations made on the vegetable species already published in Dr. Hayden's reports, and which European authors are disposed to consider as Miocene, from the number of leaves of our Eocene flora, not only homologous, but identical, with Miocene species of Europe.

The American Eocene, moreover, is identical with that of Europe by general characters. I do not believe that the divisions of our geological groups have to be controlled by European classifications. It is advisable, however, especially on account of the diversity of the conclusions indicated by botanical and animal paleontology, to mention still a few points of analogy remarked in the distribution and composition of the Eocene of both continents.

The Flysh or Eocene of Switzerland is mostly a compound of shales, here and there interlaid by sandstone strata of great thickness and even passing locally to massive sandstone, where the slate-beds disappear. This formation extends all along the northern base of the Alpine chain in different degrees of thickness, in proportion to the amount of denudation to which it has been exposed. It enters the valleys, especially borders them, in constant and immediate superposition to the Cretaceous. On the northern base of the same chain, it is present, too, in basins of limited extent, where the Upper Cretaceous strata have been left for its support. The various strata of this Eocene formation are, according to their vicinity to primitive rocks, changed by heat to a certain degree. And the top of these measures is *overlaid by a conglomeratic compound of materials derived from rocks of all the older formations, all rolled pebbles, and in pieces varying in size from that of a walnut to that of the fist.** In this formation, too, valuable beds of lignite are found; and these, though not as richly developed as in the Eocene of this continent, have sometimes a thickness of 6 feet, and have furnished combustible materials for a long time. The lignite of Niederhorn, 5,700 feet above the sea, has been worked since the former century, and is now used at Bern for the production of illuminating gas. The Eocene group of the Paris basin has also some rich beds of lignite. Does not this read like a true epitome of the descriptions given of our Eocene?

This brings forward again what I consider the last unanswered question in relation to the distribution of the American Eocene. Its base is everywhere ascertained as immediately resting upon the Upper Cretaceous; the lower sandstone is recognized as either a massive homogeneous compound or as interlaid at different places by beds of lignite or of shale. The

* Herr Urwelt der Schweitz, p. 241.

fossil flora, with some difference, has the same characters in the strata connected with these lignite-beds, at all the stations. The group is therefore satisfactorily limited so far, but where does it pass to a higher division of the Tertiary or to the Miocene? I have already remarked that I consider the conglomerate formation seen at Evanston and other localities as the upper beds of the Eocene. But I have not myself found any positive proof of this assertion, and as these conglomerates have been referred to different groups according to the strata which they appear to cover, the assertion is contestable. The observations, however, of Dr. Hayden, who, after years of careful field explorations, has become the true interpreter of the geology of the Rocky Mountains, will supply this last evidence. In beginning his description of the Green River Group, and in marking its superposition to the Eocene sandstone, he says:*

This interesting valley (Henry's Fork) is filled with beds which show a perfect conformity. The first bed is a yellow-brown, rather fine-grained sandstone, dipping 75° a little west of north. Then comes a series of yellow and light-gray arenaceous or marly clays, with beds of yellow-brown and light-gray sandstones projecting somewhat above the surface. Alternating with these layers of sandstone are quite thick beds of pudding-stone and conglomerate composed of round pebbles of all the older formations. These conglomerate beds are intercalated among the sandstone through 300 or 400 feet in thickness, and are probably of Upper Eocene age. Above them are at least 500 feet of sandstone which have a diminished dip 20° to 30°, and then pass up into the calcareous layers of the Middle Tertiary of Green River group.

The relative position of the conglomerate as underlying the Green River Group is thus positively ascertained. Comparing this with what has been described and marked in the section of Evanston, Cheyenne, Gehrung's in Colorado, the lignite basin of the Arkansas Valley near Cañon City, the Santa Fé marls, the Gallisteo group, &c., such remarkable analogy is seen in the composition and geological distribution of these conglomerates that the unity and contemporaneity of the formation becomes evident.

Mr. Lesquereux follows his descriptions of species with a table giving the distribution of the species, a brief abstract of which is here presented. He refers the Lignitic beds of Washakie, Carbon Station, Evanston and Sage Creek to the *Upper* Eocene; those of Raton Mts., Golden, Marshall's Mine, etc., California, Black Butte, Spring Cañon and some other localities to the Lower Eocene. In the following table U stands for Upper Eocene, L for Lower, M for Mississippi, where the Lignitic beds of the same age are at the bottom of the Tertiary; E^1 for European Eocene and E^2 for European Miocene.

* F. V. Hayden's Geological Report, 1870, p. 69.

Spheria lapidea Lx.		L			
Myricæ Lx.		L			
Sclerotium pustuliferum H.	U				
rubellum Lx.		L			
Opegrapha antiqua Lx.		L			
Chondtites subsimplex Lx.		L			
bulbosus Lx.		L			
Delesseria fulva Lx.		L			
incrassata Lx.		L			
lingulata Lx.		L			
Halymenites striatus Lx.		L			
major Lx.		U	L		E^1
minor F. O.		L			E^1
Omoclea sensibilis L.		L			
Pteris anceps Lx.		L			E^2
erosa Lx.		L			E^2
Aspidium Fischeri H.					
Sphenopteris Eocenica E.		L			E^1
Gymnogramma Haydeni Lx.		L			
Lygodium compactum Lx.		L			
Fern, species		U			
Equisetum limnosum (?) L.		L			
Taxodium occidentale Ny.		L			
dubium St.		U			E^2
Glyptostrobus Europeus Br.		L			E^2
Sequoia Heerii Lx.		U			
Langsdorfii Br.		L			E^2
Thuja gracilis Ny.		L			
Abietites dubius Lx.		L			
Abies setigera Lx.		L			
Salisburia binervata Lx.		L	M		
Arundo Gœpperti A. Br.		L			E^2
Phragmites Oeningensis A. Br.		U	L		E^2
Alaskana H.		L			
Juncus, species		U			
Cyperites angustior A. B.		L			E^2
Cyperus Chavanensis H.		U			E^2
Carex Berthoudi Lx.		L			
Similax grandiflora U.		U			E^2
obtusangula H.		L			E^2
Sabal Grayana Lx.		M			
Campbellii Ny.		L			E^2
Goldiana Lx.		L			
Flabellaria Zinkeni H.		L			
latania H.		L			E^1
Eocenica A. B.		L			E^1
Calamopsis Danai Lx.		M			
Palmacites, species		L			E^1
Acorus brachystachys H.		U			
Caulinites sparganiodes Lx.		U	L		
fecunda Lx.		L			
Populus Arctica H.		U	L		
decipiens Lx.		U			
attenuata A. B.		U	L		E^2
cuneata Ny.		L			
cordata Ny.		L			
acerifolia Ny.		L			
Nebrascensis Ny.		L			
genetrix Ny.		L			
nervosa Ny.		L			
monodon Lx.		L	M		
æqualis Lx.		U			
Populus mutabilis repando-crenata H.	U	L	M		E^2
lancifolia H.		L			E^2
balsamoides G.		L			E^2
ovalis G.		U			E^2
latior var. transversa A. B.	U				E^2
latior var. cordifolia A. B.	U				E^2
leucophylla U.		L			E^2
Zaddachi H.		U			
Salix Grœlandica H.		L			
Evanstoniana Lx.		U			
densinervis Lx.		M			
tabellaris Lx.		M			
Myrica ambigua Lx.		L			
Torreyi Lx.		L			E^1
Alnus Kefersteinii G.	U	L			E^2
serrata Ny.		L			
Ulmus irregularis Lx.		L			
Betula caudata G.		U			E^2
Stevensoni Lx.		U			E^2
Planera microphylla Ny.		L			E^2
Celtis brevifolia Lx.		M			
Quercus angustiloba A. B.		L			E^1
Moorii Lx.		M			
Lyellii H.		M			E^2
retracta Lx.		M			E^2
chlorophylla U.		L	M		E^2
triangularis G.		L			E^2
stramineus Lx.		L			
platania H.		U	L		
æmulans Lx.		U			
negundoides Lx.		U			
drymeja U.		U			E^2
acrodon Lx.		U	L		
Wyomingiana, Lx.		L			
Olafseni H.		L			
Haydenii Lx.		U			
Gaudini Lx.		L			E^2
Ellisianus Lx.		L			
Pealæi Lx.		L			
Godeti H.		L			E^2
Laharpi G.		L			
Saffordi Lx.		M			
dubia Ny.		L			
crassinervis U.		L			E^2
Corylus grandifolia Ny.		L			
orbiculata Ny.		L			
Americana W.		L			
McQuarryi H.		U	L		
Fagus Antipofi H.		U	L		
Deucalionis U.		U			E^2
Feroniæ U.		L			E^2
ferruginea (?) M. (fruit)		M			
Ficus Schimperi Lx.		M			
cinnamomoides Lx.		M			
tiliæfolia A. B.		U	L		E^2
planicostata Lx.		L			
Clintoni Lx.		L			
asarifolia E.		L			E^2
lanceolata H.		U			E^2
oblanceolata Lx.		U			

Ficus multinervis H. ..... U ..... E²
arenacea Lx. ..... U ..... E²
Gaudini Lx. ..... U .....
spectabilis Lx. ..... L .....
corylifolia Lx. ..... L .....
ulmifolia Lx. ..... L .....
Haydenii Lx. ..... L .....
auriculata Lx. ..... L .....
Morus affinis Lx. ..... U .....
Platanus nobilis Ny. ..... L .....
Raynoldsii Ny. ..... L .....
Haydenii Ny. ..... L .....
heterophylla Ny. .....
Guillelmæ G. ..... U L ..... E²
aceroides G. ..... U L ..... E²
Coccoloba lœvigata Lx. ..... U .....
Laurus obovata W. ..... L ..... E²
pedata Lx. ..... L M .....
Persea lancifolia Lx. ..... M .....
Benzoin antiquum H. ..... L ..... E²
Cinnamomum affine Lx. ..... U L M .. E²
Mississippiense Lx. ..... U L M .. E²
Scheuzeri H. ..... U L ..... E²
Eleagnus inæqualis Lx. ..... M .. E⁵
Banksia Helvetica H. ..... M .. E²
Aristolochia cordifolia Ny. ..... L .....
Andromeda Grayana H. ..... U .....
dubia H. ..... M .. E²
reticulata H. ..... L .....
vaccinicefolia U. ..... M .....
Diospiros lancifolia Lx. ..... U .....
stenosepala H. ..... L .....
brachysepala H. ..... L ..... E²
anceps H. ..... L ..... E²
Sapotacites Americanus Lx. ..... M .....
Echitonium Sophiæ (?) Web. .. L ..... E²
Viburnum marginatum Lx. ..... L .....
Wymperi H. ..... L .....
contortum Lx. ..... L .....
dichotomum Lx. ..... L .....
asperum Ny. ..... L .....
lanceolatum Ny. ..... L .....
Fraxinus denticulata H. ..... L .....
Prunus Carolinianus Mx. ..... M .....
Aralia triloba Ny. ..... L .....
Cornus incompletus Lx. ..... L .....
acuminata Ny. ..... L .....
Studeri H. ..... U ..... E²
rhamnifolia, ... L ..... E²
Nyssa lanceolata Lx. ..... L .....
Cissus lævigatus Lx. ..... L .....
lobato-crenatus Lx. ..... L .....
Vitis tricuspidata H. ..... L ..... E²
Olriki H. ..... U .....
Islandica H. ..... L .....
Magnolia, species .....
Hilgardiana Lx. ..... U L M .....
laurifolia Lx. ..... M .....
Lesleyana Lx. ..... L M .....
ovalis Lx. ..... M .....
cordifolia Lx. ..... M .....
Magnolia Inglefieldi H. ..... L .....
Asimina Eocenica Lx. ..... U .....
leiocarpa Lx. ..... M .....
Terminalia radobojensis U. ..... L ..... E²
Eucalyptus Haeringiana E. ..... L .....
MacClintockia Lyallii H. ..... L .....
Dombeyopsis trivialis Lx. ..... L .....
occidentalis Lx. ..... L .....
obtusa Lx. ..... L .....
acquifolia G. ..... L ..... E²
Acer, species ..... L .....
trilobatum H. ..... U ..... E²
var productum H. ..... E²
secretum Lx. ..... U .....
Negundo triloba Ny. ..... L .....
Sapundus affinis Ny. ..... L .....
membranaceus Ny. ..... L .....
undulatus A. B. ..... M .. E²
caudatus Lx. ..... L .....
Aleurites Eocenica Lx. ..... L .....
Ceanothus fibrillosus Lx. ..... L .....
Paliurus Colombi H. ..... U .....
Zizyphoides Lx. ..... L .....
Zizyphus Meekii Lx. ..... U .....
hyperboreus H. ..... U .....
Berchemia parvifolia Lx. ..... L .....
Rhamnus elegans Ny. ..... L .....
marginatus Lx. ..... M .....
obovatus Lx. ..... U L .....
salicifolius Lx. ..... L .....
intermedius Lx. ..... L .....
rectinervis H. ..... L ..... E²
Dechenii W. ..... L ..... E²
Cleburni Lx. ..... L .....
Goldianus Lx. ..... L .....
var. latior ..... U L .....
discolor Lx. ..... L .....
acuminatifolius W. ..... L .....
deletus (?) H. ..... L ..... E²
Fischeri Lx. ..... L .....
Tilia antiqua Ny. ..... L .....
Rhus deleta H. ..... U ..... E²
Evansii Lx. ..... U .....
nervosa Ny. ..... L .....
bella H. ..... L .....
Xanthoxyium dubium Lx. ..... L .....
Juglans appressa Lx. ..... U .. M .....
Saffordiana Lx. ..... M .....
acuminata (?) H. ..... U L ..... E²
rugosa Lx. ..... U L .....
obtusifolia (?) H. ..... U ..... E²
thermalis Lx. ..... L .....
rhamnoides Lx. ..... U L .....
Schimperi Lx., and fruit .. L .....
Smithsoniana Lx. ..... L .....
Baltica (?) H. ..... L .....
denticulata H. ..... U L ..... E²
Carya antiquorum Ny. ..... U L .....
Cercis Eocenica Lx. ..... L .....
Cassia concinna Lx. ..... U L .....
phaseolites U. ..... L .. E¹E²

Among the species of the Lignitic beds, thirty-two are stated by Lesquereux to occur also in the Arctic; and, of these Arctic species, *Sequoia Langsdorfii*, *Phragmites Oeningensis*, *Poacites lævis*, *Cyperites Deucalionis*, *Carex tertiaria*, *Populus lancifolia*, *Alnus Kefersteini*, *Quercus Lyellii*, *Q. drymeja*, *Fagus Deucalionis*, *Ficus tiliæfolia*, *Platanus Gulielmæ*, *P. aceroides*, *Cinnamomum Scheuchzeri*, and *Juglans acuminata*, have been afforded by the *Miocene* of Europe Of the few European Eocene species found in the Lignitic beds, none have been reported from the Arctic.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Velocity of Sound in Gases as a means of determining their Molecular Weights.*- The fundamental importance of molecular weight in modern chemical theory gives interest to any methods looking toward its more convenient or more accurate determination. Heretofore, the molecular weight of a body has been determined from its vapor-density, from its diffusibility, or from its specific heat. Bender now proposes to use the velocity of sound to accomplish this result. In gases, this velocity has the well-known relation to their density expressed by the formula $v=\sqrt{\frac{e\,s}{\delta}}$, in which e represents the elasticity of the gas, s the coefficient 1·41, obtained by dividing the specific heat at constant pressure by the specific heat at constant volume, and δ the density. For any other gas of density δ' we should have $v'=\sqrt{\frac{e\,s}{\delta'}}$; whence $v:v'::\sqrt{\delta'}:\sqrt{\delta}$, or the velocities of sound in the two gases are inversely proportional to the square root of the densities. Now since e is the same for all gases under similar conditions, and since, by Avogadro's law, the molecular weights of gases are proportional to their densities, it follows that the velocity of sound in any gas is inversely proportional to the square root of its molecular weight. In order to measure the velocity of sound in the given gas, Bender proposes to make use of the exceedingly ingenious method of Kundt.* A glass tube about a meter long is filled with the gas, some lycopodium powder† is thrown in, and the ends of the tube are hermetically sealed. If now this tube be grasped at its middle point and a wet cloth be drawn over it from the center toward the end, it will be thrown into longitudinal vibrations, and the lycopodium dust will arrange itself in a series of heaps at the nodal points. Now, since the distance between two nodes represents half a sound wave in the given gas, the number of such sound waves is one-half the number of nodes. But the length

* Pogg. Ann., cxxxv, 337. Tyndall on Sound, pp. 202–209.

† Mr. W. E. Geyer uses successfully precipitated silica, well dried.

of the sonorous wave in glass is double that of the tube. Hence the number of nodes or half waves in the gas within the tube, bears the same relation to the tube itself, or a half-wave in glass, that the number of waves in the gas bears to the number in glass. Moreover, the number of vibrations per second being the same in both, the velocity of sound in the two media must be as the number of waves. For example, if the tube contains 16 nodes, a half wave in the enclosed gas is $\frac{1}{16}$ as long as a half wave in the tube; whence it follows that the velocity of sound in the gas is $\frac{1}{16}$ of that in the glass. If the tube be grasped midway between its center and one of the ends, it gives, when rubbed, the octave of the first note, and the number of nodes is doubled. By using a series of tubes containing air, carbonic gas, illuminating gas, hydrogen and ether vapor, respectively, Kundt observed that the number of dust heaps, and therefore the velocity of sound, in each, was represented by the numbers 32, 40, 20, 9 and above 50. Or taking the velocity in air as unity, the velocities in the other gases are 0·8, 1·6, 3·56 and 0·64 respectively. These numbers correspond closely with the inverse squares of the densities of these gases, except in the case of the ether vapor, which, as the experiment was conducted at the ordinary temperature of the air, was not a true gas. In order to apply the method to cases requiring higher temperatures, Bender suggests the use of Kundt's improved method, in which the vibrating tube or rod slides within a wider glass tube in which the dust heaps are formed. The following table shows the results which this sound-method is capable of giving:

Gas.	Mol. formula	Mol. weight.	$\sqrt{\text{Mol.wt.}}$	Velocity.	$\sqrt{\text{Mol.}} : \sqrt{H_2}$.	Velocity in gas : V. in H.
Air	----	----	----	1092′	----	----
Oxygen	O_2	32	5·65	1040′	4 : 1	1 : 4
Hydrogen	H_2	2	1·41	4164′	----	----
Carbonic gas	CO_2	44	6·63	858′	4·7 : 1	1 : 4·8
Carbonous oxide	CO	28	5·29	1107′	3·7 : 1	1 : 3·7
Hyponitrous ox.	N_2O	44	6·63	859′	4·7 : 1	1 : 4·7
Ethylene	C_2H_4	28	5·29	1030′	3·7 : 1	1 : 4·0

These results coincide very well with those required by theory.—*Ber. Berl. Chem. Ges.*, vi, 665, June, 1873. G. F. B.

2. *On the existence of Sulphurous Chloride.*—MICHAELIS and SCHIFFERDECKER have succeeded in preparing and isolating sulphurous chloride, SCl_4. 67·5 grams pure S_2Cl_2, cooled to −20° or −22° was treated with a slow stream of dry chlorine gas for ten hours, the whole apparatus being tared so that the increase of weight could be observed. At the end of this time the gas ceased to be absorbed, a quantity amounting to 106 grams having been taken up. The formula SCl_4 requires 106·5 grams. It was analyzed by withdrawing a portion from the vessel containing the mass, and decomposing this with nitric acid, the chlorine and sulphur both being determined. As the mean of two analyses, the substance contained 81·59 of chlorine, and 18·41 of sulphur; theory

requires for SCl_4, 81·61 Cl and 18·39 S. Sulphurous chloride is a mobile, yellowish-brown liquid, essentially lighter in color than hyposulphurous chloride, SCl_2. Withdrawn from the freezing mixture, it evolves chlorine with effervescence, becoming so cold that the tube containing it, though immersed in a freezing mixture at $-10°$, covered itself, in the concentrated salt solution, with a thick crust of ice. After the boiling ceased, the liquid, removed from the freezing mixture—the surrounding air being at 0°—showed a temperature of $-12°$, which it retained sensibly for an hour. On saturating S_2Cl_2 with chlorine at various temperatures and analyzing the product, the authors determined the rapidity of the dissociation of SCl_4. Sulphuric oxide acts on sulphurous chloride thus:

$$SCl_4+(SO_3)_2=SOCl_2+S_2O_5Cl_2.$$

Equal molecules act thus:

$$SCl_4+SO_3=SOCl_2+SO_2+Cl_2;$$

then the thionyl chloride acts on the SO_3:

$$SOCl_2+S_2O_6=SO_2+S_2O_5Cl_2.$$

Sulphurous chloride therefore actually exists at low temperatures, and like phosphoric chloride easily dissociates into SCl_2 and a molecule of chlorine.—*Ber. Berl. Chem. Ges.*, vi, 993, Sept., 1872.

G. F. B.

3. *On Sulphur Oxytetrachloride.*—Millon long ago described white crystals resulting from the action of moist chlorine upon sulphur chloride; and Carius confirmed the fact. Michaelis and Schifferdecker have recently attempted its production by Millon's method; but obtained only a yellowish pasty mass. Reflecting upon the matter, they concluded that a substance of the composition $S_2O_3Cl_4$ could have but two possible rational formulas:

$$\overset{IV}{S}Cl_3\cdots O\cdots\overset{VI}{S}O_2Cl$$

or

$$\overset{VI}{S}Cl_3O\cdots O\cdots\overset{IV}{S}OCl.$$

In case the former formula were the true one, the body ought to be formed by the action of sulphurous chloride upon sulphuric chlorhydrate thus:

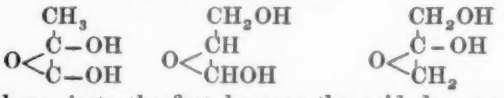
$$SCl_4+SO_2\left\{\begin{matrix}OH\\Cl\end{matrix}\right.=SO_2Cl\cdots O\cdots SCl_3+HCl.$$

Experiment resulted in the production of the compound at once in almost the theoretical amount. Sulphuric chlorhydrate was prepared by the action of chlorine upon a mixture of phosphorous chloride and sulphuric acid, and was mixed in equal molecules with the sulphurous chloride in a freezing mixture, a stream of chlorine being passed through it. Hydrochloric acid was evolved, and a white solid collected, first on the delivery tube and then on the walls of the vessel. When the contents of the flask have become semi-solid, the temperature is raised to $-13°$, and the current of chlorine continued with frequent agitation. After complete solidification, the flask is removed from the freezing mixture, the chlorine is continued till the mass becomes white, and is then dis-

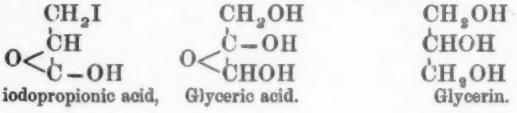
placed by carbonic gas. From 135 grams S_2Cl_2 and 233 grams SO_3HCl, 480 grams (instead of 508) $S_2O_3Cl_4$ were obtained. Sulphur oxytetrachloride is a white crystalline substance, with a peculiar pungent odor, strongly attacking the mucous passages. Cold water decomposes it with hissing, yielding sulphuric, sulphurous and hydrochloric acids. It fuses at 57°, evolving chlorine and sulphurous oxide, a portion at the same time volatilizing and condensing in fine white needles. By keeping, even in hermetically sealed tubes, it changes to a yellow liquid, possibly its isomer above given. With CS_2, it evolves $COCl_2$.—*Ber. Berl. Chem. Ges.*, vi, 996, *Sept.* G. F. B.

4. *On the Isomerism of the Lactic acids.*—WISLICENUS has recently published the results of several years' research upon the isomerism of lactic acid. He has proved that sarco-lactic acid is not a simple body but is a mixture of two different acids, easily separable from each other by the different solubility of their zinc salts in dilute alcohol. The one which is most abundant, is not identical either with ethylene-lactic acid, with ethylidene-lactic acid, or with the acid obtained from β iodopropionic acid, as is shown by its rotatory power and also by the different solubility of its salts and the different quantities of crystal water which they contain. The other acid appears to be identical with that derived from β iodopropionic acid, though also different from ethylene and ethylidene-lactic acids. This latter acid was first prepared from β iodopropionic acid by Beilstein, by the action upon it of moist silver oxide. He gave it the formula $C_{12}H_{22}O_{11}$ and the name hydracrylic acid. The author prepared it after his method, taking care not to add the silver oxide in excess or to boil it too long. The filtrate from the excess of silver, almost neutralized with sodium hydrate and evaporated, became no more strongly acid nor evolved acid vapors. The dry mass was extracted with boiling 95 per cent alcohol, which dissolved it almost completely, leaving a small residue of sodium dipimalate, acrylate, and dihydracrylate. This solution on cooling deposited crystals of sodium hydracrylate, which were purified by recrystallization from hot alcohol. These crystals are anhydrous and have the formula $C_3H_5NaO_3$; they are very deliquescent, and melt without loss at 142°–143°. Heated to 300°, they lose a molecule of water and a body is produced having the composition of sodium acrylate, but mixed with isomers which take up water again and regenerate the hydracrylate. The calcium, the zinc, the zinc-calcium and the silver salts of this acid and the acid itself are described. The latter on heating yields acrylic acid, and not a trace of lactide. On oxidation, hydracrylic acid yields neither glyceric acid as a glyceric aldehyde would do; nor malonic acid as ethylene-lactic acid does. Chromic acid and nitric acid converted it into carbonic, formic and oxalic acids. Silver oxide gave once carbace-toxylic acid, but generally oxalic and glycollic acids. Melted potassium hydrate produced formic, acetic, oxalic and glycollic acids. Heated with iodhydric acid in closed tubes, β iodo-

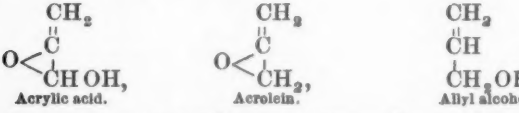
propionic acid was regenerated. On the question of its rational constitution, Wislicenus remarks: that as there can exist only two monobasic and diatomic acids $C_3H_6O_3$ containing the group COOH, and these two are known, being respectively ethylene and ethylidene-lactic acids, it follows that hydracrylic acid, differing as it does from both of these, must contain a different grouping. He therefore maintains that the carboxyl group COOH, is not the only one which can give an acid character to a molecule; but that the group C_2OOH or better $O<\begin{matrix}C\\C-OH\end{matrix}$ not only may do so, but actually does so in the case of hydracrylic acid. Of the three formulas possible upon this hypothesis,



the author rejects the first because the acid does not give the iodoform reaction and cannot therefore contain a methyl group; and the third because it would lead to an improbable formula for acrylic acid. The second formula being accepted, the following formulas are derived for the bodies related to hydracrylic acid:



β iodopropionic acid, Glyceric acid. Glycerin.



Acrylic acid. Acrolein. Allyl alcohol.

The author reserves to a subsequent paper the results of the investigation of the other constituent of the sarco-lactic acid.—*Ann. Ch. Pharm.*, clxvi, 3, Jan., 1873.—*Bull. Soc. Ch.*, II, xx, 22, July. G. F. B.

5. *On the Synthesis of a new Propionic acid.*—BERTHELOT showed several years ago that potassium hydrate absorbed carbonous oxide readily, producing potassium formate thus:

$$KOH+CO=CHO\,OK.$$

If now the alkali-alcoholates be employed, he conceived that the acids of the fatty series might be formed thus:

$$C_nH_{2n+1}\,OK+CO=\left\{\begin{matrix}C_nH_{2n+1}\\CO\,OK\end{matrix}\right.$$

His early experiments showed an absorption, but formate and not propionate—ethyl alcohol being employed—was obtained. This result was attributed to the presence of water in the alcoholate, and pure barium alcoholate—a substance in whose alcoholic solution water in the least trace, precipitates barium hydrate—was substituted. It slowly absorbed carbonous oxide, 8 c.c. of solu-

tion containing 1·5 grams barium oxide, absorbing 60 c.c. of the gas in 27 days, the resulting barium salt being soluble in the alcohol. Its analysis is peculiarly difficult, since it is destroyed by the least trace of water. The results gave the formula $C_3H_5Ba'O_2$. Hence the new body is isomeric with barium propionate, from which it is easily distinguished by its decomposition into alcohol and barium formate by the action of the water:

$$C_3H_5Ba'O_2+H_2O=C_2H_5OH+CHO\,OBa'.$$

The barium salt of common propionic acid is insoluble in alcohol. Berthelot gives it the name ethylformic acid and recognizes it as the type of a new class of acids isomeric with the fatty series and distinguished from these by being decomposed by water into alcohol and formic acid.—*Ann. Chem. Phys.*, IV, xxx, 139, Sept., 1873. G. F. B.

6. *On a new constituent of Urine.*—While seeking to determine the metamorphosis undergone by certain aromatic substances in the animal organism, BAUMSTARK obtained crystals of a new urinary constituent, having characteristic properties. It was first observed in the urine of a dog fed with benzoic acid, then in icteric urine and subsequently in normal urine. The urine is evaporated to a syrup, extracted while still warm copiously with absolute alcohol, filtered, the alcohol distilled off, the residue acidulated with hydrochloric acid and agitated with ether to remove hippuric acid, made alkaline with ammonia, treated with basic lead acetate, filtered, freed from lead by H_2S, evaporated to a syrup and allowed to stand. Besides urea, other crystals separate and remain undissolved on treatment with alcohol. Recrystallized from hot water, the substance appears in white prisms resembling hippuric acid, fusing at 250° and evolving white vapors in a tube, having an alkaline reaction and an odor of ethylamine. Analysis leads to the formula $C_3H_8N_2O$. It forms salts with acids, forms sarcolactic acid when treated with nitrous acid, and evolves ethylamine and ammonia when boiled with barium hydrate. Hence, the author proposes for it the rational formula:

$$NH_2\cdots CO\cdots C_2H_4\cdots NH_2.$$

—*Ber. Berl. Chem. Ges.*, vi, 883, July, 1873. G. F. B.

7. *On the Passage of gases through Colloid membranes of vegetable origin.*—M. A. BARTHÉLEMY performed the following experiments to prove that those of Graham on the dialysis of gases through caoutchouc could be verified on natural vegetable colloid films, especially on the cuticular surfaces of leaves, thus justifying the important part he makes the cuticle play in the absorption of carbonic acid by plants.

Everyone knows the *Begoniaceæ* with leaves spotted with white, which are cultivated in greenhouses. These white spots are, he maintains, only elevations of the epiderm upon a layer of nitrogen.

The leaves of certain varieties, very thin on the living plant, are reduced, on fading during the winter in darkness, to the condition of a pellicle endued with elasticity and representing almost noth-

ing but the cuticular layers. It was these colloid membranes which served to repeat Graham's experiment. Except in a few modifications of detail, he followed strictly the course of that illustrious physicist.

First, to ascertain by the dialysis of air alone that the membrane is intact, presenting no rents, three experiments were made on the 16th, 17th and 18th of March. They gave the following results at the end of six hours :—

	16th.	17th.	18th.
Vol. of gas collected,	5·2 cm³	5·5 cm³	7·0 cm³
Vol. of O absorbed by pyrogallate of potash,	1·9 "	2·3 "	2·2 "
Proportion of oxygen,	·36 "	·41 "	·31 "

Although the proportions of oxygen present a rather wide deviation owing to the difficulty of repeating the experiments under the same conditions of external pressure, temperature, and, especially of moisture, the conclusion may be drawn that oxygen passes more rapidly than nitrogen, and that air thus dialyzed contains on the average about 36 per cent of oxygen. This number is a little below that found by Graham with caoutchouc.

This verification made and this important result obtained, he next compared the velocities of the three gases which interest us most; for this purpose, after forming a current of carbonic acid above the membrane, he marked the point to which the mercury descended at the end of one hour; then substituting nitrogen or oxygen, he noted the time it took the mercury to descend again to the same level.

In four experiments made with different membranes, he obtained the following results:—

	1st.	2d.	3d.	4th.
CO^2	1ʰ	1ʰ	1ʰ	1ʰ
N	15ʰ	13ʰ 40ᵐ	15ʰ 30ᵐ	14ʰ
O	6ʰ	6ʰ 20ᵐ	7ʰ	5ʰ 40ᵐ

The experiments made under conditions of pressure, temperature, and moisture, which doubtless were not identical, yet agree sufficiently well with those of Graham, and allow us to conclude that the natural colloid surfaces of vegetables have for carbonic acid an *admissive power* which is thirteen to fifteen times as great as that of nitrogen, and six or seven times that of oxygen.

Some days after he repeated the experiment with carbonic acid, perfectly dry, and found for its velocity compared with nitrogen numbers varying from nine to eleven; it seems then that dry carbonic acid passes less rapidly than when moist.

Replacing the vegetable film by caoutchouc, he obtained a similar result. The difference in the case of dry oxygen and nitrogen is less marked.

He remarks, in conclusion, that these experiments prove the dialysis of carbonic acid through the cuticle of leaves, just as much as those of Dutrochet on membranes and aqueous solutions prove endosmose by cellules, or the experiments on absorption made by

M. Dehérain with porous vessels, to which the academy accorded one of its highest rewards. In a word the *cuticular* respiration seems to be sufficiently proved by the presence of this membrane on all the organs, by the analogy of the physical and chemical constitution of this membrane with caoutchouc, by the experiments of Graham and the measures of the passage of gases through colloid membranes, and finally by the experiments of M. Boussingault, who attributes to the upper surfaces of leaves, destitute of stomata, a decomposing power greater than that of the lower surface covered with these minute apertures.—*Comptus Rendus*, lxxvii, 427, August, 1873. E. C. P.

8. *Relation between the atomic weight, the specific gravity and the hardness of the metallic elements.*—M. S. Bottone was led on theoretical grounds to admit that the natural measure of the hardness of any metallic element was the specific gravity divided by the atomic weight; and this conclusion seems verified by experiment. Taking as a measure of the hardness, the time required by a steel plunger with a uniform rotary motion to penetrate the metal to a certain depth, he found numbers, as the following table shows, which differ from theory only by amounts comparable with the errors of observation:

	Spec. Grav.	Atomic Wt.	Calc.	Expt.
Manganese	8·01	55·0	·1457	·1456
Cobalt	8·5	58·8	·1446	·1450
Nickel	8·28	58·8	·1408	·1410
Iron	7·7	56·0	·1375	·1375
Copper	8·66	63·4	·1364	·1360
Palladium	11·8	106·6	·1107	·1200
Platinum	21·5	197·4	·1090	·1107
Zinc	7·0	65·2	·1077	·1077
Indium	72·8	74·0	·0983	·0984
Gold	19·3	197·0	·0980	·0979
Silver	10·4	108·0	·0963	·0990
Aluminum	2·25	27·4	·0821	·0821
Cadmium	8·6	112·0	·0768	·0760
Magnesium	1·74	24·0	·0726	·0726
Tin	7·2	118·0	·0619	·0651
Thallium	11·86	204·2	·0574	·0565
Lead	11·38	207·0	·0550	·0570
Sodium	0·93	23·3	·0401	·0400
Calcium	1·58	40·0	·0394	·0405
Potassium	0·86	39·1	·0221	·0230
Diamond	3·5	12·0	·2917	·3010

—*Les Mondes*, xxxi, 720. E. C. P.

9. *On a periodicity of Cyclones and Rainfall in connection with the Sunspot periodicity.*—At the recent meeting of the British Association, Mr. Chas. Meldrum presented a table of the cyclones of the Indian Ocean, between the latitudes of 0° and 25°S. From 1847 to 1873, 237 such storms are recorded, and in their occurrence show a marked preponderance during the periods of maximum num-

ber of sun-spots. Three such maxima occurred in 1849, 1860 and 1872, and regarding each as extending over three years, the number of cyclones is 26, 39 and 36, while in the corresponding minima of 1856 and 1867, the number is only 13 and 21. 24 hurricanes were also recorded in Mauritius between 1731 and 1850, of which 17 occurred during maxima, and seven only during minima sun-spot periods.

The examination of 93 tables of rainfall renders probable a similar periodicity in this respect also.—*Nature*, Oct. 9th. E. C. P.

10. *Secondary Currents and their Applications.*—Mr. GASTON PLANTE has been engaged for some time in the study of the form of galvanic battery called a secondary couple. He immerses two long strips of lead, rolled in a helical form and separated by thick cloth, in dilute sulphuric acid, and connects them with a primary battery of two Bunsen cells. Decomposition takes places with the formation of peroxide of lead, and after a short time removing the primary, and connecting the terminals of the secondary battery, a powerful current passes for several minutes; the apparatus forming, in fact, a sort of condensor to store up the electricity generated in the primary battery.

In a memoir recently presented to the French Academy, he states that the action is greatly improved by the following method of preparing the plates. The primary battery is first connected to charge the plates; the current is then broken, and they are allowed to rest for some time, and then reconnected with poles reversed. The plates of lead thus undergo a change not only on the surface, but throughout their mass, by the formation and reduction of the peroxide. The liquid remains unchanged, for such couples have been used for years without replacing the acid or the lead; in fact, they seem to improve with time. When the current is broken, the deposits on the surface, either of oxidized or of reduced metal, acquire a crystalline texture and a strong adherence which helps protect the subjacent layers.

A couple thus prepared, with sheets of lead half a meter square, after being charged with two Bunsen cells, will heat to redness for twenty minutes a platinum wire half a millimeter in diameter and a wire a fifth of a millimeter in diameter for an hour, without any communication with the primary source, and even forty-eight hours after it has been charged.

A battery with a surface of one and a half square meters will in like manner heat a platinum wire to redness a month after it has been charged.

Although two Bunsen cells are required to prepare the plates, yet once prepared they may be charged by a very feeble primary current acting always in the same direction. Many applications are suggested for these batteries. For instance, a small battery will heat a platinum wire so that a gas burner may be lit a hundred times without recharging, and with a larger battery three or four thousand consecutive illuminations have been obtained. They may also be associated with electric bells so as to work with the

same battery. Even more, if the primary current is too feeble to ring them, the secondary battery can by its accumulated work cause them to sound for a short time, thus forming a sort of electrical flywheel or accumulator of power.

A curious effect is produced by charging a secondary couple with a Gramme magneto-electric machine. The latter is then stopped by the hand, when, on removing the resistance, it starts under the influence of the secondary couple and begins to revolve in the *same* direction in which it was turned to charge the battery. This result, which is precisely the opposite of what we should at first expect, is simply explained as follows. When the Gramme machine is turned, it generates a current in a certain direction. If now a battery is introduced which will send a current through it in the same direction, the machine becomes an electro-magnetic engine and by Lenz law will turn backward or in the opposite direction from before. But the secondary couple reverses the current, and hence the machine turns in the same direction as at first.—*Les Mondes.* E. C. P.

11. *Sound and Music: A non-mathematical Treatise on the Physical Constitution of Musical Sounds and Harmony, including the chief acoustical discoveries of Professor Helmholtz;* by SEDLEY TAYLOR, M.A., late Fellow of Trinity College, Cambridge. London: Macmillan & Co. 1873, pp. xii, 219, 8vo.—As the author states in his preface, this treatise, "portions of which have been delivered in lectures at the South Kensington Museum, the Royal Academy of Music, and elsewhere, aims at placing before persons unacquainted with mathematics an intelligible and succinct account of that part of the theory of sound which constitutes the physical basis of the Art of Music."

In thus endeavoring to remove the difficulties which non-mathematical readers find in attempting to follow and comprehend the expositions of the complicated phenomena of sound and music, the author has not lost sight of the strict scientific method. Beginning with the simplest examples of periodic motion, by an easy and natural development of the subject, the reader is led on to the consideration of waves of various kinds, as resulting either from simple vibratory motions, or from several such combined; thence to the composition of complex sounds, and the causes of the characteristic qualities of the notes of the different musical instruments and the human voice, and finally to the subject of harmony, including the discussion of the varying characters of the different concords, and discords, and of their employment in music.

The successive topics are rendered more intelligible to the unscientific reader by a great variety of illustrations, many of which are peculiarly felicitous and elegant. In this respect, although little is added to the theory of acoustics, the book is fresh and original. The most unscientific reader cannot fail to be attracted by so simple and clear a presentation of an interesting subject, while the skilled acoustician may derive from it many valuable hints and suggestions. A. W. W.

12. *Objections to the views of Mr. Moon on the measure of work;* by R. J. ADCOCK. (Editorial Correspondence.)—In the October number of this Journal, page 301, I find an article taken from the Philosophical Magazine for Sept., 1873, written by Mr. Robert Moon, in which he brings some apparent objections to the definition and measure of work, as used by mathematicians and engineers, and in modern school text books,—for instance Professor Bartlett's Mechanics, Prof. Moseley's Engineering and Architecture,—which objections unanswered in your Journal might retard the advancement of science.

In his quotation from Prof. Maxwell, "along a path" is left out of the definition of work, which is not done in the standard works above mentioned, and is necessary to the idea of mechanical work. Then making the correction the definition stands: "To work is to overcome a resistance continually recurring along some path." And work is therefore measured, when the moving force or resistance is constant, by the force into the distance moved. Now Mr. Moon having, I suppose, the above definition and measure of work, draws the very absurd inference, that when a constant force F acts in a given direction upon a body free to move, during the time T, that because "the resistance which is being overcome at each epoch of time" is the same, that therefore the work done in equal intervals of time will be the same throughout the motion. He says this conclusion follows without giving any reason for it, except that after showing that the work done in this case in equal intervals is not the same, in the latter part of the paragraph (1), he says the definition "implies that the work done in equal intervals of time will be equal." Now the definition, instead of implying any such thing, says nothing about time. It shows that when the force is constant, that the work is equal for equal intervals of distance. The work of a constant force over a given distance is independent of the time of motion; the time depends upon the magnitude of the mass moved and upon its initial velocity, in the case of free motion, and may have any values.

Paragraphs (2) and (3) are correct, except that he calls V a variable quantity, after having assumed it as one of the arbitrary constants. (4) is objectionable for using the term work in a sense different from the received one, and for affirming that the reasonableness of a conclusion would be difficult to establish after having just given the proof of it.

To the elementary principle of *vis viva*, that twice the quantity of work=the living force,—stated more at length, twice the quantity of work expended upon a mass between two positions in space is equal to the difference of the *vis viva* at those two positions, whatever be the path between them, straight or curved, and whatever be the time of motion,—there can be no valid objection. Every objection which I have seen, when understood, is merely an example of the application of the principle.

Lenox, Warren County, Illinois, October 18th, 1873.

13. *Chemistry, Inorganic and Organic: with Experiments;* by CHARLES LOUDON BLOXAM, of King's College, London, &c. 225 Illustrations; reprinted from the second and revised English edition. Philadelphia (Henry C. Lea), 1873. 8vo, pp. 699.—The edition of Prof. Bloxam's Chemistry, noticed a year since (iv, 496), now appears to have been first issued in this country by Messrs. Lindsay & Blackiston, from the English types—from sheets in fact printed in London and sent over to this country—and was not *a reprint*, as was then supposed. The present issue, by Mr. Lea of Philadelphia, is an American reprint of the same English edition, and so far as we have compared the two there is no verbal difference between them, although the American edition has gained in bulk a little by difference in typography. The evident regret with which the author abandons the old chemical notation for the atomic system, the "beauty and harmony of which he thoroughly appreciates," and "the immense assistance it has afforded in research," he acknowledges, is a good example of the tenacity of grasp with which old ideas hold even the most intelligent minds—after years of familiarity. We have already expressed our high appreciation of Prof. Bloxam's valuable work.

II. GEOLOGY AND NATURAL HISTORY.

1. *Contributions from the Laboratory of the University of Pennsylvania.* No. 1. *Corundum, its alterations and associated minerals;* by F. A. GENTH. 56 pp. 8vo. (From the Proceedings of the Am. Phil. Soc., Sept. 19th, 1873.)—Dr. Genth presents in this memoir the results of a great amount of labor in the analysis and study of the rocks of the Corundum localities, especially those of North Carolina. He describes the geological position and relation of the chrysolite of the region, and shows that it is true chrysolite, and not a hydrous mineral allied to villarsite, as made out by Prof. C. U. Shepard; and that it is only sometimes hydrous as a result of alteration. He gives analyses by himself of spinel, smaragdite, zoisite, oligoclase, fibrolite, staurolite, damourite, ephesite and lesleyite, paragonite, jefferisite, chlorite of different kinds, pattersonite (shown to be near thuringite), chloritoid, margarite, besides descriptions and analyses of the new chlorite-like minerals *kerrite, maconite, willcoxite* and the margarite-like species *dudleyite.* He gives evidence for believing, from the relations of other species in and about corundum crystals, and the character of their own crystallizations, that the following species have been derived from the alteration of *corundum: spinel, diaspore, beauxite,* (opposing Hunt's view of the derivation of corundum from beauxite), *gibbsite* (probably), *opal, zoisite, tourmaline* (in all probability), *fibrolite, cyanite, damourite, staurolite* (probably), *pyrophyllite, ephesite* and *lesleyite* (which are shown to be mixtures containing a large percentage of free corundum, confirming Prof. Brush's results), *paragonite, euphyllite, jefferisite, chlorite, pattersonite, chloritoid, margarite, lazulite.* Dr. Genth concludes as follows:

That at the great period when the chromiferous chrysolite beds (in part subsequently altered into serpentine, etc.) were deposited, a large quantity of alumina was separated which formed beds of corundum;

That this corundum has subsequently been acted upon and thus been changed into various minerals, such as spinel, fibrolite, cyanite, and perhaps into some varieties of feldspar, also into tourmaline, damourite, chlorite and margarite;

That a part of the products of the alteration of corundum still exists in the form of large beds of mica—(damourite) and chlorite—slates or schists;

That another part has been further altered and converted into other minerals and rocks, such as pyrophyllite, paragonite, beauxite, lazulite, etc.

2. (1) *Geological Survey of Illinois, A. H. Worthen, Director.* Volume V, Geology and Palæontology: Geology by A. H. Worthen and James Shaw; Palæontology by F. B. Meek and A. H. Worthen. 619 pp. large 8vo, with 32 lithographic plates. Springfield (Illinois), 1873.

(2) *Report of the Geological Survey of Ohio.* Part II of Volume I, Palæontology. Descriptions of Invertebrate Fossils of the Silurian and Devonian Systems, by F. B. Meek. Descriptions of Fossil Plants and Fossil Fishes, by J. S. Newberry. 402 pp. large 8vo. Columbus, 1873.

These two volumes will be welcomed by the geologists of the world as among the most important contributions to Palæontology which have yet been made.

The Illinois Report is the fifth volume of the series, and the fourth in which a large part of the pages is devoted to the organic remains of the rocks of the State. This new volume makes the whole number of plates of fossils—and admirable plates they all are—*one hundred and thirty*—a very noble gift from the State to science, and the record of a very large amount of faithful labor and of thorough knowledge of the subject, as well as of artistic skill. This fifth volume, for the first 320 pages, is occupied with details with regard to the geology of several of the more northern counties of the State by Mr. Worthen and Mr. James Shaw, and many important facts are given respecting the lead mines, the various rock formations, the drift, building material, soil, prairies, etc. The fossils described are species from the Subcarboniferous limestones and the Coal measures. The chapter on these comprises descriptions of over one hundred and twenty-five species of Crinoids—figured from specimens mostly of wonderful perfection—adding largely to the number illustrated in the earlier volumes; also several Palæechinoids and Star fishes, and many Mollusks. The fidelity and science of Mr. Meek appear in all parts of the paleontology.

The General Geology of the State of Ohio having been described, the volume now issued is devoted to the Paleontology of the State, which subject is here only commenced. The State is especially

rich in fossils of the Cincinnati group of the Lower Silurian, in fishes of the Devonian and Carboniferous, and in the remains of Carboniferous vegetation. Mr. Meek, who has done an immense amount of good work in American Palæontology, here describes from the Cincinnati group 33 species of Crinoids, nearly all new, and 7 of star fishes (genera *Stenaster* and *Protaster*), besides a large number of species of Brachiopods and other Mollusks, and several Trilobites; and also Mollusks and Trilobites of the Devonian. The species are all finely figured from drawings mostly by Mr. W. H. Holmes. Next follows the section by Prof. Newberry on the fossil fishes of the Devonian and Carboniferous, and on coal plants. A valuable review of the classification and distribution of American Palæozoic fishes is first given. The species of fishes described from the Corniferous limestone includes 11 of Selachians and 8 of Ganoids. There are other species also from the Hamilton, Chemung and Catskill groups, and also from the Subcarboniferous and Carboniferous beds. Twenty-one species were obtained from Linton, a Carboniferous locality. The plates represent well (from drawings by Prof. G. K. Gilbert) the head of the huge *Macropetalichthys*, the jaws and teeth of the great *Onychodus*, and of the still larger and more remarkable *Dinichthys*, the great teeth of several species of *Rhynchodus*, spines of various ancient sharks, and the plates of *Placoderms*, and the forms of many small Ganoids. The chapter on plants is especially interesting for the large number of kinds of fruits described, the figures of which occupy four plates.

Prof. Newberry states that twelve nearly perfect skeletons of the *Dicotyles compressus*, a hog-like extinct species related to the Mexican peccary, have recently been obtained near Columbus, and that a description of it with plates will appear in another volume.

3. *United States Geological Survey of the Territories*, F. V. Hayden, Geologist in charge. *Photographs of* 1873.—We have received an interesting selection from the photographic views taken by Prof. Hayden's Survey in Colorado this summer, and hasten to lay before the readers of the Journal some account of the operations of the survey in this department.

The photographic work was this year again in the charge of Mr. W. H. Jackson, who has approved in previous campaigns his skill as a workman, his enterprise and persistence as an explorer, and his good judgment in the selection of his subjects. To his party were joined, during most of the summer, the collectors in natural history. They began work near the end of May, about Long's Peak; the snow prevented them from ascending the mountain itself so early. Their views of the peak, however, and of the beautiful little Estes Park at its foot, were very successful. They then moved southward through the Front Range as far as Gray's Peak, getting the whole panorama on the way, and taking from Gray's itself a connected series of views around the horizon. The same was done again from Pike's Peak, to which the party next moved,

visiting on their way Chicago Lake, Bear Creek, the Platte Cañon, and the remarkable tracts of fantastically worn sandstone known as Monument Park and the Garden of the Gods. From there, they traversed South Park, and, after again taking panoramic views from Mt. Lincoln, joined near Fairplay the party of the chiefs of the survey, and accompanied them to Weston Pass, Twin Lakes, and other points on the valley of the Arkansas, across the National Range and into the Elk Mts., and finally up the Arkansas and beyond its head waters to the Mount of the Holy Cross, returning thence to Denver and breaking up on the 5th of September. Panoramic views were taken from La Plata Mt. in the National Range, and from Whiterock Mt. in the Elk group.

The total number of views taken during the campaign is nearly 300, half of them being stereoscopic, half the remainder 4×7 inch plates, and the rest the large 9×14 inch plates. They fairly cover the region traversed, in its various aspects. The interests of science were especially considered in the selection of subjects, and it was designed that the panoramic views should combine with the drawings of Mr. Holmes, the artist of the survey (drawings, it is believed, rarely equalled for their comprehensiveness, minute accuracy, and artistic truth of expression), to make the reported facts thoroughly reliable, and to bring before the apprehension of lovers of Nature, whether for her beauty or her history, the grand scenery of the grandest part of the Rocky Mts. The high panoramas will need, in part, to be judged by their intent to display the structure of regions which few have visited or can expect to visit. The lens is far behind the eye in its power to appreciate the distances in such views, and to discover the far off and faint. And while there is plenty of sublimity in scenes where heights of 12, 13 and 14 thousand feet count by scores, and vast amphitheaters and deep gorges are on every hand, they are not precisely *picturesque*, in the proper sense; they are not manageable into pictures. Those who have seen both, give the preference in this respect to the Sierra Nevada over the Colorado mountains. Especially the great volcanic peaks of the western coast, raising their majestic isolated cones from a low base, are more powerfully impressive than ranges where lines of peaks and crests of immense but equal altitude ascend from bases already at 7 to 10 thousand feet; there are few summits in Colorado which are lifted more than 6000 feet above their immediate surroundings. The barrenness of these mountains, too, as regards both white snow and green vegetation, in the mass, detracts from their effectiveness. Almost everywhere, the snow lies in summer only in lines and patches, which, though of no small absolute dimensions, are petty as compared with the great mountain masses. The only marked exception, this summer (when the snow was much less, to be sure, than the average), was the eastern amphitheater of one of the great peaks of the Elk Mts., where there is an unbroken sheet a full mile wide, and covering half a mile of downward slope. This does not appear among the views taken; the survey were able to

approach the mountain only from the rear. Even here, of course, is no glacier; the snow reaches the valley below only as water, after collecting in one of those intensely green lakes which dot the high slopes of these mountains, as of the Alps; the combined beauty and grandeur of the Swiss ice-rivers is altogether wanting. At the same time, the evidences of former glacial action on an immense scale are abundant and striking, and views of them are among the most valuable of Mr. Jackson's pictures. There is, for example, the picture (taken from 1300 feet above it) of the great glacier-trough leading down from the Holy Cross Mt., and filled for miles with *roches moutonnées* on the grandest scale: sheep-backs up to 50 feet high and hundreds of feet long, all rounded and smoothed, and crowding one another so closely as to be almost impassable. The nearer views, taken from amid these ridges themselves, and showing the fallen timber with which the spaces between them are filled, give a lively sense of the delights of travelling among them. One of the most striking pictures of the series is that of this Holy Cross Mt. itself, with its white cross 1500 feet long on its front; it was to gain this view that the party (as mentioned in our October number, above, p. 299) had to climb all day with 50 pounds of apparatus on each man's back, and then to spend the night near the summit, without food or shelter. Other important glacial views are those of the great moraines at the eastern base of the National Range, along the Arkansas Valley; the most remarkable of them, stretching out from the mouth of the regular and deeply penetrating valley of Clear Creek, are two or three miles long and 700 feet high, and from the opposite heights seem as regular as railway embankments. The Twin Lakes, a few miles farther up the valley, the lovely situation and beauty of which are well illustrated by a series of views, are themselves also interesting results of glacial action, nestled between vast moraines in front and vaster mountains behind; even the narrow bar that separates them is but a terminal moraine, dropped across their basin by a peak of the retreating glacier.

In the three more easterly ranges, there is great uniformity of material; almost everything is granite and gneiss; and the variety is that of eroded form. In the National Range, especially, there is not a trace of sedimentary rock through its whole extent of 80 miles. With the Elk Mts. the case is very different; and some of their striking and peculiar features are brought clearly to light by these views. They have a wonderful variety of coloring also, which unhappily photography is unable to reproduce. From the top of Italian Mt., for example (so named from its presenting in brilliancy the Italian colors, red, white, and green), nearly the whole structure of the group can be read in the contrasts of coloring: the light gray of the granitic and eruptive nucleus, with the numberless peaks of sandstone about it, the strata conspicuously dipping away in every direction, and in two shades of red, a lighter and a darker, the latter a rich maroon color. There are

few more beautiful scenes than the Grand Teocalli, as seen from the mouth of the short valley (some three miles long, and a mile broad between high walls) which leads from it down to the East River: a vast pyramid, 2,700 feet high, of most regular form, in bare steps and courses of maroon red at the summit, and with the same color, blushing, as it were, with a most peculiar effect, through the thin grassy covering of its lawn slopes.

Besides these grander views, illustrative of the geography and geology of the region, there is the usual proportion, in the usual variety, of minor items of scenery, such as waterfalls, lakes, natural bridges, bits of ravine, and strange rock forms. Conspicuous among these last are the almost incredible shapes of eroded sandstone columns in Monument Park. W

4. *Synopsis of New Vertebrata from the Tertiary of Colorado, obtained during the summer of* 1873; by Prof. E. D. COPE. Extracted from the 7th Annual Report of the U. S. Geological Survey of the Territories, F. V. Hayden, U. S. Geologist in charge; dated Washington, October, 1873. [Received at New Haven about October 15th.] 19 pp. 8vo.—These few pages, from the forthcoming Report of Dr. Hayden, are to a large extent a list of the species of vertebrates made out from the collections of the summer, with references to Prof. Cope's "Paleontological Bulletins" Nos. 15, 16. They contain also descriptions of some other new mammals, including species of *Paramys*, *Canis*, *Mastodon*, *Symborodon* (allied to Rhinoceros), and of other genera; and also some Ophidia and Lacertilia.

No copies of the numbers of the Paleontological Bulletins of Prof. Cope referred to in the pamphlet have reached this city from the author.

5. *Precious Opal from a new Mexican locality.*—Signor D. Mariano Barcema, Secretary of the "Sociedad Mexicana de Historia Natural," gives, in the 39th number (second volume) of La Naturaleza, a publication issued by the Society, under date of May 8th, 1873, an account of opals from a new locality. The locality is at the Hacienda of Esperanza, 10 leagues northwest of San Juan del Rio, in the State of Queretaro. It was first found in 1855, but not announced or appreciated before 1870. The opals are described as of the first quality, and as of all varieties, milk opals, fire opals or girasols, "harlequins," and various kinds of the richest precious or Hungarian opals. The specimens sent the writer fully sustain Signor Barcema's descriptions. The "harlequins" are exceedingly beautiful, being a fire opal spangled within with brilliant green points, or like a most delicate mosaic, as Signor Barcema expresses it, of fire-red and metallic emerald. The precious opals vary from perfect pellucidity with green and fire-red flashes, through pale and deep reddish shades, to opaque white; and the last kind, with its no less brilliant green and red opalescence, is of remarkable beauty. One variety of the precious opal gives violet reflections; and another emerald with dark ultramarine.

These opals are described as occurring disseminated through a reddish quartziferous porphyritic rock; it looks like a tufaceous porphyritic rock. The ordinary reddish color of the opals is described as varying with the color of the containing rock. The fact is mentioned that the opals are more or less hygroscopic, and change in specific gravity with the moisture of the atmosphere.

J. D. D.

6. *Movements of the Glands of Drosera;* by A. W. BENNETT. A paper read at the Bradford meeting of the British Association, Sept. 20th.—A clear account of the facts, of late years familiar, thanks to Mr. Darwin, now confirmed by independent observations. Mr. Bennett observed not only the bending in of the glands upon the body of the insect, but that "the sides of the leaf had also slightly curved forward, so as to render the leaf itself more concave." With us, the leaves do much more than that. As well in *D. rotundifolia* as in *D. longifolia*, the end of the leaf folds over upon the base, or nearly, like a shut hand, thus fairly enclosing the captive. Plants showing this daily were growing, in wet moss, in our class-rooms through the summer. When we published Mrs. Treat's account of this infolding of the leaf, in this Journal, in November, 1871, and afterward in How Plants Behave, the discovery was thought to be new. But we find that the infolding of the leaf, as well as the intrusion of the glands, was discovered by Roth in 1779, and published by him in his Beyträge zur Botanik, in 1782, part 1, pp. 60–66. The only real addition to our knowledge—this old knowledge, recently reproduced—is that contained in the latter part of Mr. Bennett's communication, which is substantially to the effect that *Drosera* acts upon bits of raw meat just as upon a living insect, but is motionless toward inorganic bodies, and, in his experiments, to bits of wood and of worsted. In the report of Mr. Bennett's communication, given in Trimen's Journal of Botany, and elsewhere, no allusion is made to the history and record of all these discoveries. But as Dr. Sanderson, in a succeeding communication, referred to this last point as one which had been clearly made out by Mr. Darwin, it is as well to state that the following paragraph refers to him.

"Another and most practiced observer, whose observations are not yet published, declares that the leaves of the common Round-leaved Sundew act differently when different objects are placed upon them. For instance, if a particle of raw meat be substituted for the living fly, the bristles will close upon it in the same manner; but to a particle of chalk or wood they remain nearly indifferent." (How Plants Behave, p. 44.)

We have for several years been urging Mr. Darwin to publish the results of these and other (some of them still more curious) observations and experiments upon *Drosera* and *Dionæa*. A. G.

7. *Fly-catching in Sarracenia.*—Referring to our note on this topic in the August number, p. 149, we have, first, an oversight to correct. For "Mr. Hill of North Carolina," read Mr. B. F. Grady, Jr., of Clinton, North Carolina. Our correspondent in-

forms us that he published an account of his observations three years ago in the Carolina Farmer, published at Wilmington; and that this was copied into a Montgomery (Alabama) paper, but he is not aware that it attracted further attention. The author of the paragraph referred to, in the English translation of Le Maout and Decaisne's book, does not remember his authority for the statement there made. In a recent letter, Mr. Brady gives an account of observations repeated last summer upon the pitchers of *Sarracenia flava*. "These, brought into the house, and kept fresh by the immersion of the base in water, showed the saccharine secretion most abundantly about a quarter of an inch above the junction of the lid with the rim. . . . . Many flies settled on the lids and feasted on the saccharine narcotic. Evident signs of intoxication were manifested in each case, by their breaking loose repeatedly before tumbling into the gulfs."

Sarracenia Drummondii is the species which most closely resembles *S. flava* in the shape and structure of the pitcher. We now learn from a letter addressed by Dr. Chapman to Mr. Canby, that the former is well aware of a similar excretion in that species. "On the inside of the hood," he writes, "above its junction with the tube, there is a very faintly sweetish secretion, scarcely perceptible to the taste, which is very attractive to insects; and, as I do not detect any of this within the tube, I wonder how it happens that so many insects are entrapped, since they could easily fly away from the open hood." Mr. Brady's observations are here to the point; but wider confirmation is desirable, especially as to the narcotic character of the secretion, which needs abundant evidence. And the other species should now be scrutinized.

A. G.

8. *Engelmann; Notes on the Genus Yucca.* Extr. from *Trans. Academy of Science of St. Louis*, vol. iii. April, 1873.—This modest title comprises the principal results of Dr. Engelmann's long study of a difficult genus of plants. Pursuing his botanical investigations now for many years only in the intervals and spare moments of a busy and exacting professional life, Dr. Engelmann has made them tell most effectively and advantageously upon the science which numbers him as a distinguished votary, by taking up one subject at a time, and investigating it as thoroughly as possible. In this way he has mastered, in turn, our *Cuscutæ* (upon which his earliest essay was published in this Journal, thirty-one years ago, and his latest was a full monograph of all the known species throughout the world), our *Cactaceæ*, our Mistletoes, Euphorbias, *Junci*, *Callitriches*, etc., not to speak of several other genera or groups, or taking account of his sedulous and long-continued study of our Oaks and, above all, of our *Coniferæ*. Nor need we look to this as the close of the series, but rather see before him "fresh fields and pastures new," and wish for him more time to expatiate in them. Upon the principle, "to him that hath shall be given," he well deserves it, as having accomplished far more in these rescued moments than others who could mainly devote their days as well as nights to scientific work.

Almost without exception these monographs relate to difficult subjects, and such as require long-protracted investigation. This is also true of the present essay upon the genus *Yucca*. It is not a large one, only a dozen species being clearly made out; but those of long cultivation in Europe have been much confused, and recent ones described without flowers, while fruit is rarely formed out of their native stations, and dried specimens of any completeness are difficult to make, so that means of comparison are much restricted.

The true anthesis, as is now shown, is nocturnal, the flowers remaining half closed during the day. The anthers, with comparatively large and few grains of glutinous pollen, open rather earlier than the flower. The tips of the style, which were naturally taken for stigmas, are now shown to be functionless, the stigmatic surface being the moist and glutinous lining of a stylar tube, which extends downward nearly to the cells of the ovary and even communicates directly with them. As soon as it became evident that fertilization must depend upon nocturnal insects, it was found that they were most frequently and regularly visited by "white moths, which, usually in pairs, disported in the open flowers at dusk, and were found quietly ensconced in them when closed in day-time." Prof. Riley of St. Louis, the distinguished entomologist, was at this point associated with Dr. Engelmann in the investigation. The result has been given to the scientific world in his interesting memoir on *Pronuba yuccasella*, first read at the Dubuque meeting of the American Association for the Advancement of Science, in August, 1872, and now also published, as a sequel to Dr. Engelmann's monograph, in the Transactions of the St. Louis Academy.

"The rootstock of all the Yuccas is, under the name of *Amole*, an important article in a Mexican household, being everywhere used as a substitute for soap, as it is replete with mucilaginous and saponaceous matter, probably a substance analogous to the saponine of the *Saponaria* root. It is curious to learn that the negroes of the coast of South Carolina repeatedly destroyed Dr. Mellichamp's carefully observed clumps of Yuccas, in order to obtain the saponaceous rootstock." In Colorado Territory we found that *Yucca angustifolia* is as generally called "Soap-plant," as is the *Chlorogalum* in California.

While the nature of the fruit, whether capsular or baccate, is a tribal character in *Liliaceæ* generally, *Yucca* has both kinds; and Dr. Engelmann turns this character, with accompanying differences in the seeds, to good account in the systematic arrangement of the species. The common "Spanish Bayonet," *Y. aloifolia* of the Southern States, and some related Texan and Mexican species, represent the pulpy-fruited section; *Y. brevifolia*, which ranges across the Arizonian border of the United States, has a spongy indehiscent pod, probably at first more or less drupaceous; while the Bear-Grass, *Y. filamentosa*, and its allies bear a dry capsule. It may here be recorded that the name *Y. canaliculata* of Hooker

must replace that of *Y. Treculiana* of Carrière, the latter being a name published without character, in 1858, the former described and figured in 1860, in the Botanical Magazine. The prince of Yuccas must be *Yucca baccata*, which, in its variety *australis*, forms "trees twenty-five to thirty feet high, and two or three feet in diameter, with ten or a dozen branches," or sometimes reaches to even fifty feet of elevation, according to the late Dr. Gregg, although the most northern form of it is almost stemless. Its pulpy fruits are "savory, like dates," are eaten fresh by both whites and Indians, and are cured by the latter for winter provisions. They also make a stew of the flower-buds and flowers, which Dr. Palmer found to be pleasant and nourishing. The seeds are said to be actively purgative. The fibers of the leaves are used for cordage, the trunks for palings, or are riven into slabs for the covering of huts, and the tender top of the stem is roasted and eaten.

Professor Riley's curious paper upon the mutual relations of Yuccas with *Pronuba*, a Tineideous moth that does the work of *pollination*, will be read with interest. A. G.

9. *On some remarkable Forms of Animal Life from the Great Deeps off the Norwegian Coast, partly from posthumous manuscripts of the late Professor Dr. Michael Sars;* by GEORGE OSSIAN SARS, quarto, with 6 copper-plates. Christiania, 1872.—This highly interesting and important memoir, which is written in English, contains very complete descriptions of a considerable number of the more remarkable deep-sea animals discovered by the author. The plates are excellent. The following species are described and figured: of Polyzoa, *Rhabdopleura mirabilis*, *Flustra abyssicola*; of Conchifera, *Yoldia obtusa*, *Pecchiolia abyssicola* (gen. nov.); of Cephalophora, *Dentalium agile*, *Triopa incisa*, *Goniĕolis typica;* of Annelida, *Umbellisyllis fasciata* (gen. nov.), *Paramphinome pulchella* (gen. nov.); of Anthozoa, *Mopsea borealis*, *Fungicyathus fragilis* (gen. nov.); of Spongiæ, *Trichostemma hemisphæricum* (gen. nov.), *Cladorhiza abyssicola* (gen. nov.), *Hyalonema longissimum*.

The last named species has been found during the two past summers on our own coast, at moderate depths (see page 440), and *Cladorhiza abyssicola* was dredged in the deeper parts of the Gulf of St. Lawrence last year, by Mr. Whiteaves, who sent me a specimen for identification, agreeing in size and form with the larger one figured by Sars. By a most unfortunate error, Dr. Wyville Thomson* has applied this name to an entirely different genus of sponges, and for the true *Cladorhiza* he has constituted a new genus under the name of *Chondrocladia* (op. cit. pp. 187, 188, fig. 36), although he stated (p. 49) that he had examined the types of Sars' species.

* Depths of the Sea, by C. Wyville Thomson, 1873, p. 112. The species figured by Thomson (p. 187, fig. 45) as *Chondrocladia virgata* is stouter and less branched than *C. abyssicola*, and is probably a distinct species. It should, therefore, be called *Cladorhiza virgata*.

A species belonging, apparently, to the genus *Trichostemma* was also dredged by us during the past summer, off Cape Elizabeth, in 40–70 fathoms, adhering to stones; but it is larger, less regular in form, and more setose at the surface than the species described by Sars. A. E. V.

10. *Bidrag til Kundskaben om Norges Hydroider* (Vidensk.-Selsk. Forhandlinger, for 1873), with 4 "autographic plates;" by G. O. Sars.—This paper contains a complete list of the Norwegian Hydroids, with their geographical and bathymetrical distribution; descriptions and figures of a large number of new species and genera; and a review of all the deep-water species. Many of these species are found also on the coast of New England, and the work is therefore an important one for students of American marine zoology. The peculiarly executed figures are numerous and very characteristic, though not so finely wrought as most of those for which we are indebted to the skill of the author. Among the new species described are several that we have recently dredged on the New England coast. Of these the *Hydrocium gorgonoide* of Sars (p. 24, plate IV, figs 5–15) appears to be identical with *H. robustum*, described by us in December, 1872 (this Journal, vol. v, p. 9).

The *Acaulis primarius* Stimpson is well figured (plate V, figs. 14–20), and is represented as having a small and short but distinct stem. A fact that we had also ascertained several years ago*—but in our specimens, from the Bay of Fundy, the stem is longer and very slender. A. E. V.

III. Miscellaneous Scientific Intelligence.

1. *On the Earthquake of October*, 1871, *and on a swarm of Locusts at Cordoba.* Letter from Dr. B. A. Gould, to the Editors, dated Cordoba, September 8, 1873.—Since writing you a month ago, I have received additional data concerning the times at which the severe earthquake of July 6th and 7th took place in sundry places. These confirm beyond doubt the inference that the shocks of Sunday afternoon in the northern provinces, and of the subsequent night in the western ones and Chile, were perfectly distinct phenomena, although both of exceptional severity. The want of standards of local time makes it impossible to deduce any accurate data regarding the velocity of the wave. But from Valparaiso, which receives its time from the Observatory at Santiago, the moment of first shock is reported as $2^h\ 21^m\ 30^s$. Sant. time. And from Mendoza, whither, as also to the other stations of the Transandine line, the time is transmitted weekly from this observatory, the moment is reported as $2^h\ 30^m$, which when converted into Santiago time becomes $2^h\ 21^m\ 37^s$, showing at least that the moment of occurrence at these two places could not have been very different. But from San Juan, the longitude of which differs probably by less than a minute from that of Mendoza, the time of the first shock is reported as $2^h\ 20^m$ A. M.

* Bulletin Essex Institute, vol. iii, p. 4, Jan., 1871.

I have recently been witness to one of the remarkable phenomena of this region, the passage of a swarm of locusts. On the 13th of August our attention was attracted and indeed forcibly diverted from all other objects by the myriads of large grasshoppers which filled the air, invaded the houses, and covered the ground, from which they rose like thick clouds of dust when disturbed by the approach of man or beast. Going out to observe the phenomenon more closely, I saw to the eastward what was apparently a long trail of dense black smoke, extending over 160° of the horizon, from which it extended to an altitude of about 5 degrees. The appearance differed in no respect from that of black smoke drifting from a large conflagration; but a strong field glass showed me that the servants were correct in assuring me that it was no smoke but a swarm of locusts. How wide this swarm was there was no means of judging, but from the position of the focus needed for resolving this animated nebula at its point of nearest approach, I estimated that none of the swarm passed within less than three or four miles of us. The insects were evidently transported by the wind, which blew from the north with a velocity of about ten miles an hour, and gave to the train of locusts all the wreathed and branched forms of drifting smoke. This was before 10 A. M.: how long they had been passing I know not, but the head of the column had passed far out of sight, and certainly twenty miles of its length were visible over the far-stretching pampa. They continued to pass in apparently undiminished number until the daylight failed. Meanwhile the stragglers, which had visited us in such profusion, disappeared; and the next day single specimens could with difficulty be found.

On the 1st of September the phenomenon was repeated, the insects returning from the south borne on a wind which moved at 5 or 6 miles an hour. They were descried at a distance of certainly not less than a dozen miles, moving directly upon us; but the wind hauled from S. to S.E. an hour later and saved us. The change of direction was very manifest, and the effect of the change of wind could be seen as it successively reached the different parts of the long procession. The Sierra, which extends N. and S. immediately west of Cordoba, the foothills rising at the distance of about 12 miles, barred their westward progress, and the train passed between us and the Sierra for many hours. I was able to fix the height of the swarm by sighting against the peaks, and ascertaining on the following day the distance at which they had passed. The altitude of the upper limit of the densest portion seems to have very slightly exceeded 7°, the distance of its near limit being about six miles. Thus the height of the dense nucleus seems to have been not less than 2000 ft., its width being here not more than six or seven miles, possibly less; the whole environed by a penumbra of copious stragglers. Yesterday and the day before, the north wind brought them back again for some hours of each day, but to-day the wind has returned to the south, and since I began this page they have come upon us in full force, literally darkening the sun,

and at this moment of writing there is probably not a square inch of our grounds unoccupied by them. The sunlight on the floors presents a singular aspect, the crowded little shadows streaming rapidly across it and interrupting the greater part of the light.

2. *Remarks on the chemical analyses of samples of soil from Bermuda*, by his Excellency Major-General J. H. Lefroy, Governor and Commander-in-Chief. 46 pp. 8vo, 1873.—The analyses of soils of a coral island like Bermuda have a special interest. Major-General Lefroy adopts the conclusion of Professor Wyville Thomson, that the red soil, which occurs on some parts of the island, and contains very little lime, is a result of the solution and removal of the carbonate of lime of the coral rock and the consequent leaving behind of all insoluble matters which the seawater and organic sources may have contributed to it, with perhaps some extraneous additions. The average of the results of analyses of the red soil by Johnston and Manning afford organic substances, in 100 parts, 15·41, lime 5·95, magnesia 0·36, alumina 16·94, silica, or sand and insoluble clayey matters 36·60, oxide of iron 19·58, potash 0·14, soda, chiefly as common salt, 0·03, carbonic acid (combined with lime and magnesia) 4·06, sulphuric acid 0·02, phosphoric acid 0·70, chlorine (chiefly as common salt) 0·015. The white soil of the island contains 52 per cent or more of lime and 42 or so of carbonic and with 3·8 to 5 per cent. of organic matter and small proportions of other ingredients; and it is therefore mainly carbonate of lime.

3. *Report of the Director of the New York Meteorological Observatory, Department of Public Parks, City of New York, for the year ending December 31st*, 1872. 48 pp. 8vo. New York, 1873.—The question, Has the temperature of the Atlantic States undergone modification, considered in the Report of last year, receives further consideration in this Report, with a citation and approval of the conclusions of Profs. Loomis and Newton—that there is no evidence from meteorological observations of the last seventy years of any change. The Report discusses also and illustrates by diagrams the direction in which atmospheric fluctuations cross the United States, and closes with various meteorological tables.

4. *Munificent Gift to Science.*—Lafayette College, at Easton, Pennsylvania, has recently received gifts from Mr. Ario Pardee to the amount of nearly half a million of dollars. These gifts include a building for the scientific department, erected at an expense of $250,000. "Pardee Hall" was dedicated on the 21st of October. The orator of the occasion was R. W. Raymond, President of the American Institute of Mining Engineers. The hall has a front of 256 feet, and is built of Trenton brown stone, with trimmings of the light Ohio sandstone. It has laboratories for chemical, metallurgical, mineralogical, and other scientific purposes.

5. *Rocky Mountain Observatory.*—Mr. James Lick of California, it is reported, is about to make a second great gift to Science.

He has offered to bestow upon the California Academy of Sciences an observatory, erected and equipped with the best and largest instruments, on some elevated point in the Sierra Nevada, at least 10,000 feet above the sea. In such a situation and well manned, it would work wonders in the way of astronomical discovery.

6. *Palladium.*—An ingot of this rare metal, valued at about $10,000, was exhibited at Vienna the past summer in the English department, having been extracted from about $5,000,000 platiniferous gold.—*Address of Dr. R. W. Raymond before the Am. Inst. of Mining Engineers.*

7. *Sulphur product of the World.*—In 1871 the Italian (Sicilian) mines of sulphur produced ..... 6,860,000 cwt.
The rest of the world in the same year produced .. 152,500 "

7,032.500
Equal in gross tons to 351,625

The quantity of sulphur produced from the roasting of pyrites is insignificant, this industry being occupied almost exclusively in the production of sulphuric acid.—*Ibd.*

8. *Report on the Fossil Plants of the Lower Carboniferous and Millstone Grit formations of Canada;* by J. W. Dawson. From the Reports of the Geological Survey of Canada. 48 pp. 8vo, with 10 plates.—This memoir extends greatly our knowledge of the Lower Carboniferous Flora. It also contains a list of the species of the Middle and Upper Coal Measures, and discusses the character of Sigillarioid and Lepidendroid stems.

OBITUARY.

August Breithaupt.—This venerable mineralogist died at Freiberg, Saxony, on the 22d of September, in the 83d year of his age.

His services as instructor in mineralogy commenced in 1813, with private lessons to students in the Royal Saxon Mining Academy. He was also at this time appointed Government Inspector of precious stones, and Administrator of the Mineralien-Niederloge. In 1817, on the death of Werner, he was called to complete the unfinished course of lectures in mineralogy in the academy, and in 1826, on the resignation of Mohs, he was appointed professor of mineralogy, a position he held at the time of his death, although relieved from active service several years since. For over half a century, Professor Breithaupt has been one of the most active investigators in mineralogy in Europe, describing a very large number of new species, and contributing a mass of observations of great value to science. He was the author of several mineralogical treatises, including a work on the paragenesis of minerals.

The grand collection of minerals in the Mining Academy, which he was chiefly instrumental in bringing together, remains as evidence of his untiring energy and disinterested devotion to the science of mineralogy and to the welfare of his beloved institution.

George C. Schæffer died, October 4th, at Washington, in his 59th year.

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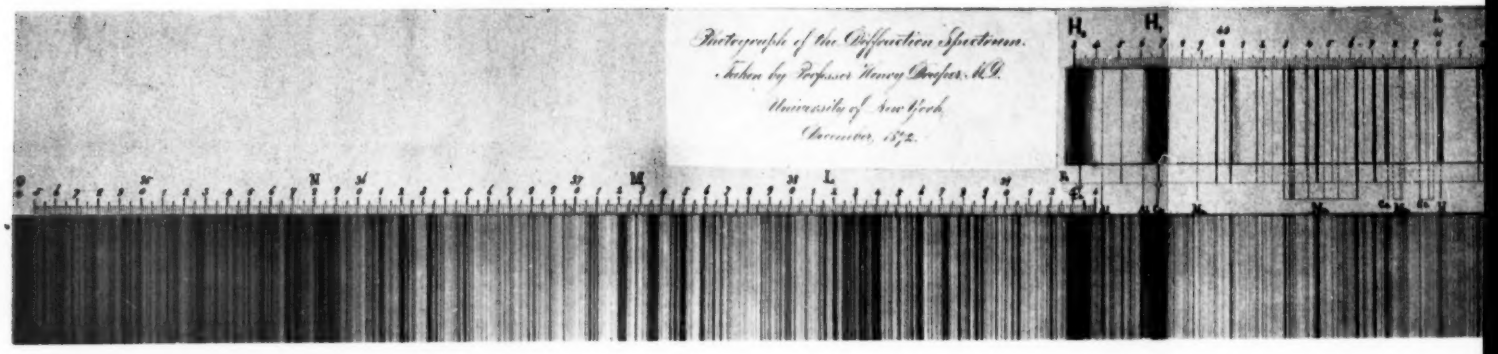
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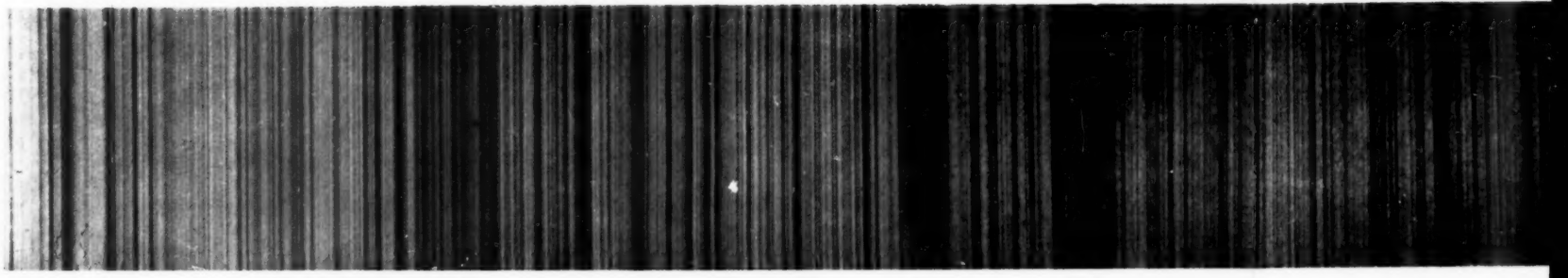

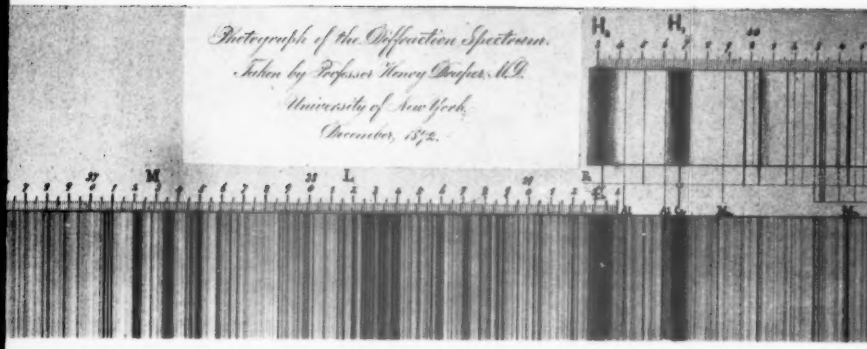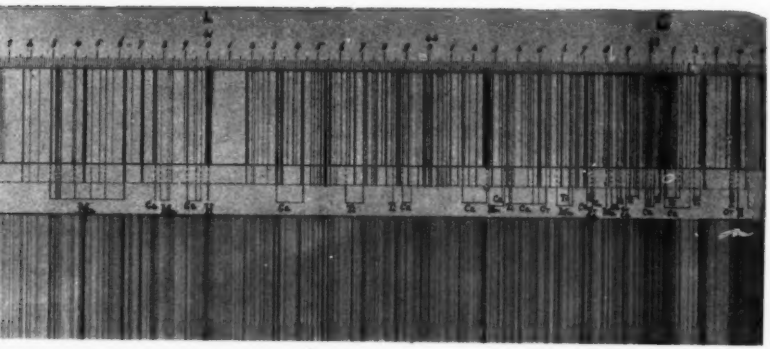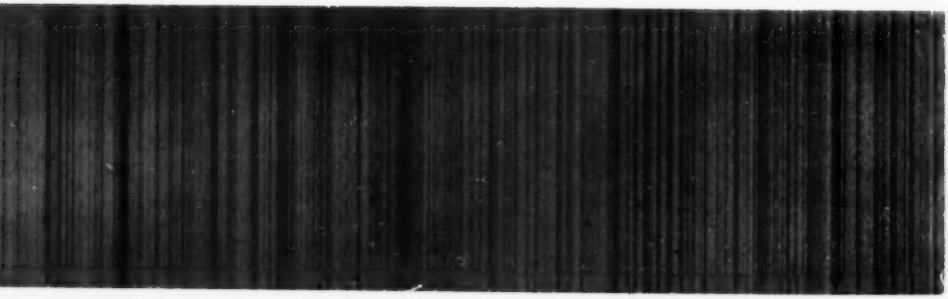
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